

NATIONAL GEOGRAPHIC

MARS

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An artist's impression of an ancient, more wintry Mars.

ART BY KEES VEENENBOS

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Secrets of the Viking Warriors Their commando bands first poured out of Scandinavia in the late eighth century, making strikes in revolutionary longships. In the centuries to come, the Vikings spread across Europe and into Central Asia and the New World. What were the innovations that propelled the Vikings to power?



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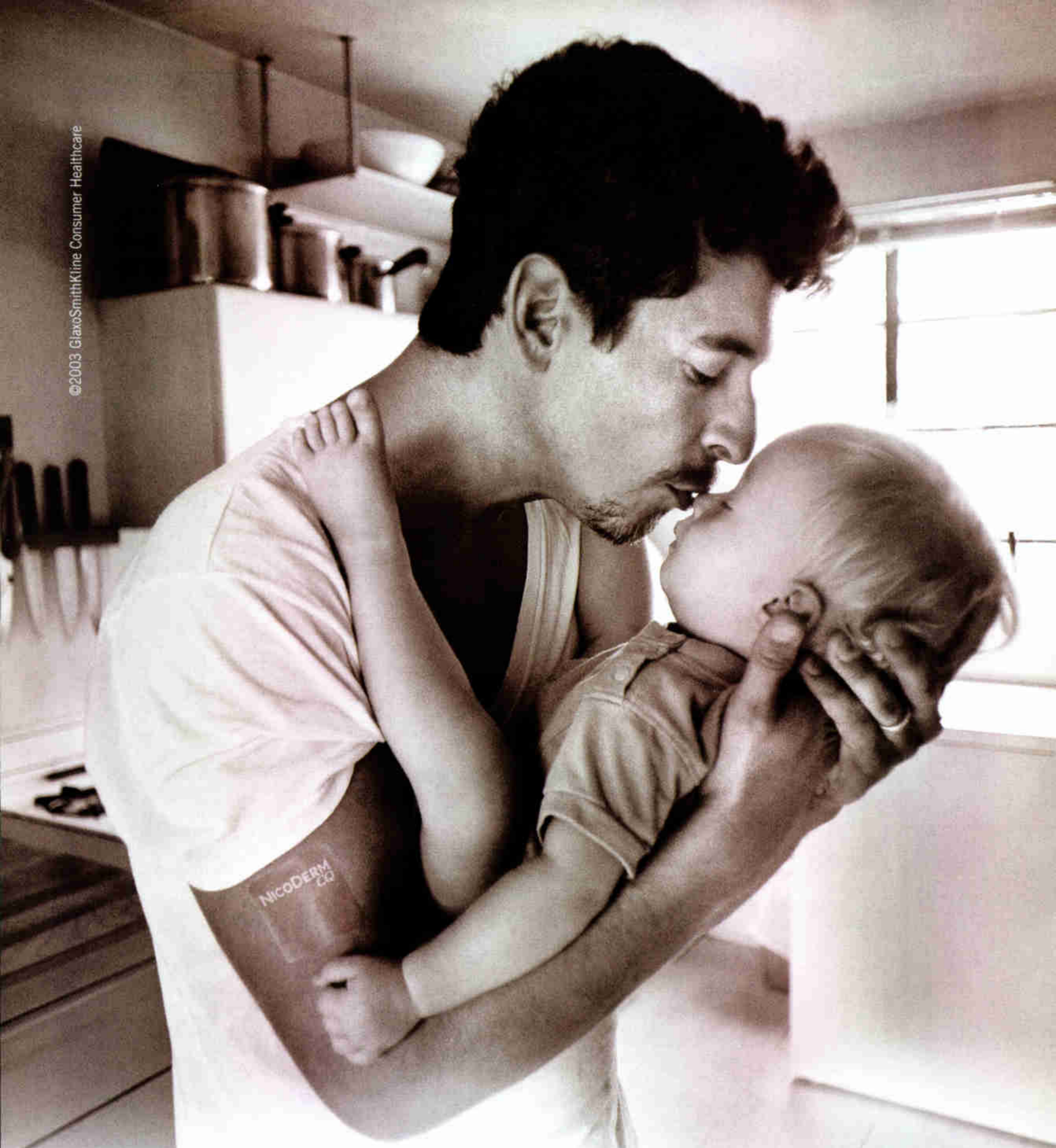
HAVE SOMETHING TO SAY?

This month give Basin, Montana's, “health mines” some competition by telling us about traditional remedies from your neck of the woods at nationalgeographic.com/magazine/0401/forums

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NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN

Struggling across the dunes of Mars always struck me as a bad way to die. Growing up in Texas, I knew dry, but nothing as dry as the Mars I read about in science fiction novels. Of course, the idea of the red planet as a menace didn't just come from paperbacks: Orson Welles's *War of the Worlds* radio broadcast in 1938 convinced some Americans that Martians were attacking New Jersey. It's to be expected, I guess, from a planet named after the Roman god of war and appearing tinged with blood to the naked eye.

For me the science fiction books and movies were all in good fun: lots more fiction than science. But we now know that creators of science fiction weren't the only ones to be wrong about Mars. For decades scientists thought the planet's surface was dead and unchanging. Yet as you'll see in our story on page 2—featuring remarkable new images and data from two orbiting spacecraft—it turns out that Mars is home to seasonal storms, dust avalanches, perhaps even snowpacks and flowing glaciers.

I hope that by the time you read this, three landers will have begun transmitting even newer information from Mars. For now, that's as close as you can get to the planet's surface. But did you know that there are surprisingly Mars-like places on Earth you can visit? Turn to Do It Yourself, a new monthly page offering ways for you to experience the subjects we cover, and you'll learn what it's like to be a Martian—without dragging yourself across any dunes.

Bill Allen

Right before your eyes, they'll be hundreds of miles away at college.



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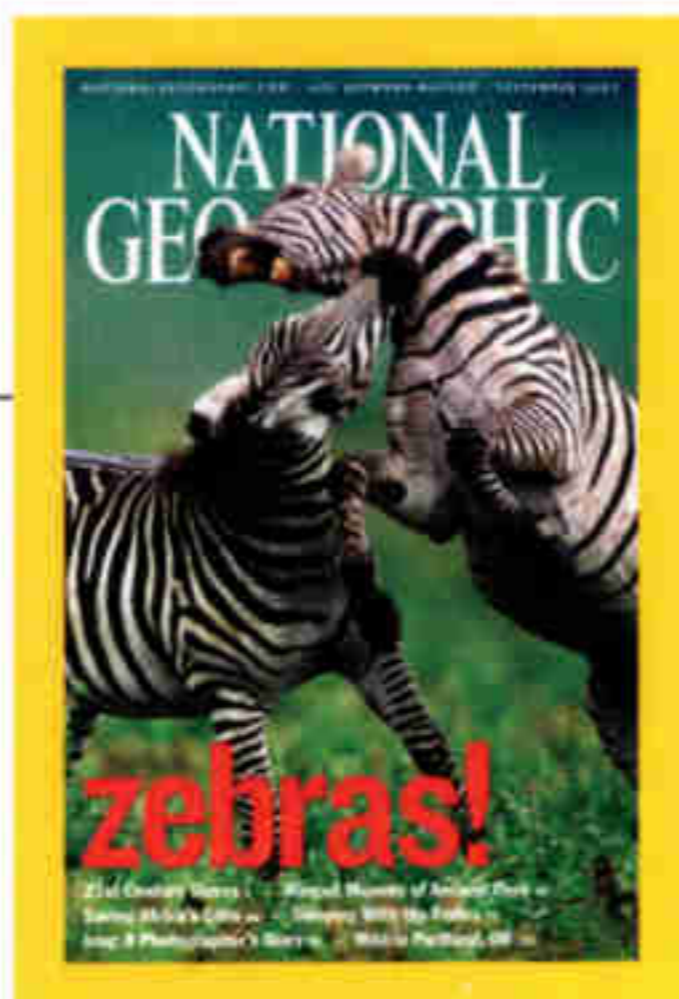
 **TOYOTA**

Vehicle shown with available equipment. ¹Toyota Vehicle Stability Control (VSC) is an electronic system designed to help the driver maintain vehicle control under adverse conditions. It is not a substitute for safe driving practices. Factors including speed, road conditions and driver steering input can all affect whether VSC will be effective in preventing a loss of control. Please see your Owner's Manual for further details. ©2003 Toyota Motor Sales, U.S.A., Inc.

Forum

September 2003

"21st-Century Slaves" and its sister story "Inhuman Profit" provoked the largest amount of favorable mail we've received on a topic since the May 1987 articles on Ukraine and Chernobyl. As for criticisms: Most came from parents who interpreted a passage in "Inhuman Profit" regarding illegal adoption in Guatemala as a condemnation of legal adoption in that country.



21st-Century Slaves

I was once one of the world's 27 million slaves. When I was seven, my village in southern Sudan was raided by northern Sudanese militiamen, who killed indiscriminately, capturing women and children. Most of my family died that day, but I was spared, only to become a slave. For the next ten years I slept beside the same animals my master made me tend during the day. I was regularly beaten and threatened with death. In 1999 I escaped and moved to the United States with the help of the United Nations refugee program. I now work with the American Anti-Slavery Group to bring attention to slavery around the world by speaking out as a survivor. Thank you for teaching your readers that this evil institution is still alive.

FRANCIS BOK
Boston, Massachusetts

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I have never been more proud of my membership in the National Geographic Society than I was when I read the article on modern-day slavery. You have saved people with your courageous article. It will make a difference, believe me.

ROBERT HARRISON
Montreal, Quebec

I was disappointed that the National Geographic Society used my dues to publish an article on slavery. Slavery is abhorrent, but it is not a topic for your magazine. If I want to read about it, I will join Amnesty International. Please keep your subject matter confined to articles of a more general geographic nature.

LOUIS DAVIS
Houston, Texas

If our government is willing to sacrifice billions of dollars and hundreds of lives for a controversial war to liberate Iraqis, shouldn't it go without saying that the U.S. should make ending slavery a priority? I hope after reading this article, people will lobby for the government to become what it says it is—the defender of freedom!

NIKOLETA PAPADOPOULOS
Natick, Massachusetts



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Asthma control that can help you breathe easier.

SINGULAIR IS SIMPLE TO TAKE. A single tablet a day helps provide effective 24-hour asthma control. It's not a steroid and it's not an inhaler. The same SINGULAIR is also approved to help relieve a broad range of seasonal allergy symptoms. For asthma, SINGULAIR should be taken once a day, in the evening as prescribed, whether or not you have asthma symptoms. SINGULAIR is available by prescription only.

IMPORTANT INFORMATION: SINGULAIR should NOT be used for the fast relief of acute asthma attacks. You should still have rescue medication available and continue to take your other asthma medications unless your doctor tells you to stop. If your doctor has prescribed a medicine for you to use before exercise, keep using that medicine unless your doctor tells you not to. If your asthma symptoms get worse or you need to increase the use of your rescue inhaler, call your doctor at once.

In clinical studies, side effects were usually mild and varied by age, and included headache, ear infection, sore throat, and upper respiratory infection. Side effects generally did not stop patients from taking SINGULAIR. Check with your doctor if you're pregnant or nursing.

Ask your doctor about SINGULAIR.
Call 1-888-MERCK-56, or visit singulair.com.

Please see the Patient Product Information on the adjacent page and discuss it with your doctor.



This product is available through the Merck Patient Assistance Program. To find out if you qualify call 1-888-MERCK-56.

ONCE-A-DAY
SINGULAIR[®]
(MONTELUKAST SODIUM)
A simple way to help control asthma.



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Patient Information
SINGULAIR® (SING-u-lair) Tablets, Chewable Tablets, and Oral Granules
Generic name: montelukast (mon-te-LOO-kast) sodium

9094216

Read this information before you start taking SINGULAIR®. Also, read the leaflet you get each time you refill SINGULAIR, since there may be new information in the leaflet since the last time you saw it. This leaflet does not take the place of talking with your doctor about your medical condition and/or your treatment.

What is SINGULAIR®?

- SINGULAIR is a medicine called a leukotriene receptor antagonist. It works by blocking substances in the body called leukotrienes. Blocking leukotrienes improves asthma and seasonal allergic rhinitis (also known as hay fever). SINGULAIR is not a steroid.

SINGULAIR is prescribed for the treatment of asthma and seasonal allergic rhinitis:

1. Asthma.

SINGULAIR should be used for the long-term management of asthma in adults and children ages 12 months and older.

Do not take SINGULAIR for the immediate relief of an asthma attack. If you get an asthma attack, you should follow the instructions your doctor gave you for treating asthma attacks. (See the end of this leaflet for more information about asthma.)

2. Seasonal Allergic Rhinitis.

SINGULAIR is used to help control the symptoms of seasonal allergic rhinitis (sneezing, stuffy nose, runny nose, itching of the nose) in adults and children ages 2 years and older. (See the end of this leaflet for more information about seasonal allergic rhinitis.)

Who should not take SINGULAIR?

Do not take SINGULAIR if you are allergic to SINGULAIR or any of its ingredients.

The active ingredient in SINGULAIR is montelukast sodium.

See the end of this leaflet for a list of all the ingredients in SINGULAIR.

What should I tell my doctor before I start taking SINGULAIR?

Tell your doctor about:

- **Pregnancy:** If you are pregnant or plan to become pregnant, SINGULAIR may not be right for you.
- **Breast-feeding:** If you are breast-feeding, SINGULAIR may be passed in your milk to your baby. You should consult your doctor before taking SINGULAIR if you are breast-feeding or intend to breast-feed.
- **Medical Problems or Allergies:** Talk about any medical problems or allergies you have now or had in the past.
- **Other Medicines:** Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, and herbal supplements. Some medicines may affect how SINGULAIR works, or SINGULAIR may affect how your other medicines work.

How should I take SINGULAIR?

For adults or children 12 months of age and older with asthma:

- Take SINGULAIR once a day in the evening.
- Take SINGULAIR every day for as long as your doctor prescribes it, even if you have no asthma symptoms.
- You may take SINGULAIR with food or without food.
- If your asthma symptoms get worse, or if you need to increase the use of your inhaled rescue medicine for asthma attacks, call your doctor right away.
- **Do not take SINGULAIR for the immediate relief of an asthma attack.** If you get an asthma attack, you should follow the instructions your doctor gave you for treating asthma attacks.
- Always have your inhaled rescue medicine for asthma attacks with you.
- Do not stop taking or lower the dose of your other asthma medicines unless your doctor tells you to.
- If your doctor has prescribed a medicine for you to use before exercise, keep using that medicine unless your doctor tells you not to.

For adults and children 2 years of age and older with seasonal allergic rhinitis:

- Take SINGULAIR once a day, at about the same time each day.

- Take SINGULAIR every day for as long as your doctor prescribes it.
- You may take SINGULAIR with food or without food.

How should I give SINGULAIR oral granules to my child?

Do not open the packet until ready to use.

SINGULAIR 4-mg oral granules can be given either:

- directly in the mouth; OR
- mixed with a spoonful of one of the following soft foods at cold or room temperature: applesauce, mashed carrots, rice, or ice cream. Be sure that the entire dose is mixed with the food and that the child is given the entire spoonful of the mixture right away (within 15 minutes).

IMPORTANT: Never store any oral granule/food mixture for use at a later time. Throw away any unused portion.

Do not put SINGULAIR oral granules in liquid drink. However, your child may drink liquids after swallowing the SINGULAIR oral granules.

What is the daily dose of SINGULAIR for asthma or seasonal allergic rhinitis?

For Asthma (Take in the evening):

- One 10-mg tablet for adults and adolescents 15 years of age and older,
- One 5-mg chewable tablet for children 6 to 14 years of age,
- One 4-mg chewable tablet or one packet of 4-mg oral granules for children 2 to 5 years of age, or
- One packet of 4-mg oral granules for children 12 to 23 months of age.

For Seasonal Allergic Rhinitis (Take at about the same time each day):

- One 10-mg tablet for adults and adolescents 15 years of age and older,
- One 5-mg chewable tablet for children 6 to 14 years of age, or
- One 4-mg chewable tablet or one packet of 4-mg oral granules for children 2 to 5 years of age.

What should I avoid while taking SINGULAIR?

If you have asthma and if your asthma is made worse by aspirin, continue to avoid aspirin or other medicines called non-steroidal anti-inflammatory drugs while taking SINGULAIR.

What are the possible side effects of SINGULAIR?

The side effects of SINGULAIR are usually mild, and generally did not cause patients to stop taking their medicine. The side effects in patients treated with SINGULAIR were similar in type and frequency to side effects in patients who were given a placebo (a pill containing no medicine).

The most common side effects with SINGULAIR include:

- stomach pain
- stomach or intestinal upset
- heartburn
- tiredness
- fever
- stuffy nose
- cough
- flu
- upper respiratory infection
- dizziness
- headache
- rash

Less common side effects that have happened with SINGULAIR include (listed alphabetically): agitation including aggressive behavior, allergic reactions (including swelling of the face, lips, tongue, and/or throat, which may cause trouble breathing or swallowing), hives, and itching, bad/vivid dreams, increased bleeding tendency, bruising, diarrhea, hallucinations (seeing things that are not there), hepatitis, indigestion, inflammation of the pancreas, irritability, joint pain, muscle aches and muscle cramps, nausea, palpitations, pins and needles/numbness, restlessness, seizures (convulsions or fits), swelling, trouble sleeping, and vomiting.

Rarely, asthmatic patients taking SINGULAIR have experienced a condition that includes certain symptoms

that do not go away or that get worse. These occur usually, but not always, in patients who were taking steroid pills by mouth for asthma and those steroids were being slowly lowered or stopped. Although SINGULAIR has not been shown to cause this condition, **you must tell your doctor right away if you get one or more of these symptoms:**

- a feeling of pins and needles or numbness of arms or legs
- a flu-like illness
- rash
- severe inflammation (pain and swelling) of the sinuses (sinusitis)

These are not all the possible side effects of SINGULAIR. For more information ask your doctor or pharmacist.

Talk to your doctor if you think you have side effects from taking SINGULAIR.

General Information about the safe and effective use of SINGULAIR

Medicines are sometimes prescribed for conditions that are not mentioned in patient information leaflets. Do not use SINGULAIR for a condition for which it was not prescribed. Do not give SINGULAIR to other people even if they have the same symptoms you have. It may harm them. **Keep SINGULAIR and all medicines out of the reach of children.**

Store SINGULAIR at 25°C (77°F). Protect from moisture and light. Store in original package.

This leaflet summarizes information about SINGULAIR. If you would like more information, talk to your doctor. You can ask your pharmacist or doctor for information about SINGULAIR that is written for health professionals.

What are the ingredients in SINGULAIR?

Active ingredient: montelukast sodium

SINGULAIR chewable tablets contain aspartame, a source of phenylalanine.

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Inactive ingredients:

- **4-mg oral granules:** mannitol, hydroxypropyl cellulose, and magnesium stearate.
- **4-mg and 5-mg chewable tablets:** mannitol, microcrystalline cellulose, hydroxypropyl cellulose, red ferric oxide, croscarmellose sodium, cherry flavor, aspartame, and magnesium stearate.
- **10-mg tablet:** microcrystalline cellulose, lactose monohydrate, croscarmellose sodium, hydroxypropyl cellulose, magnesium stearate, hydroxypropyl methylcellulose, titanium dioxide, red ferric oxide, yellow ferric oxide, and carnauba wax.

What is asthma?

Asthma is a continuing (chronic) inflammation of the bronchial passageways which are the tubes that carry air from outside the body to the lungs.

Symptoms of asthma include:

- coughing
- wheezing
- chest tightness
- shortness of breath

What is seasonal allergic rhinitis?

- Seasonal allergic rhinitis, also known as hay fever, is an allergic response caused by pollens from trees, grasses and weeds.
- Symptoms of seasonal allergic rhinitis may include:
 - stuffy, runny, and/or itchy nose
 - sneezing

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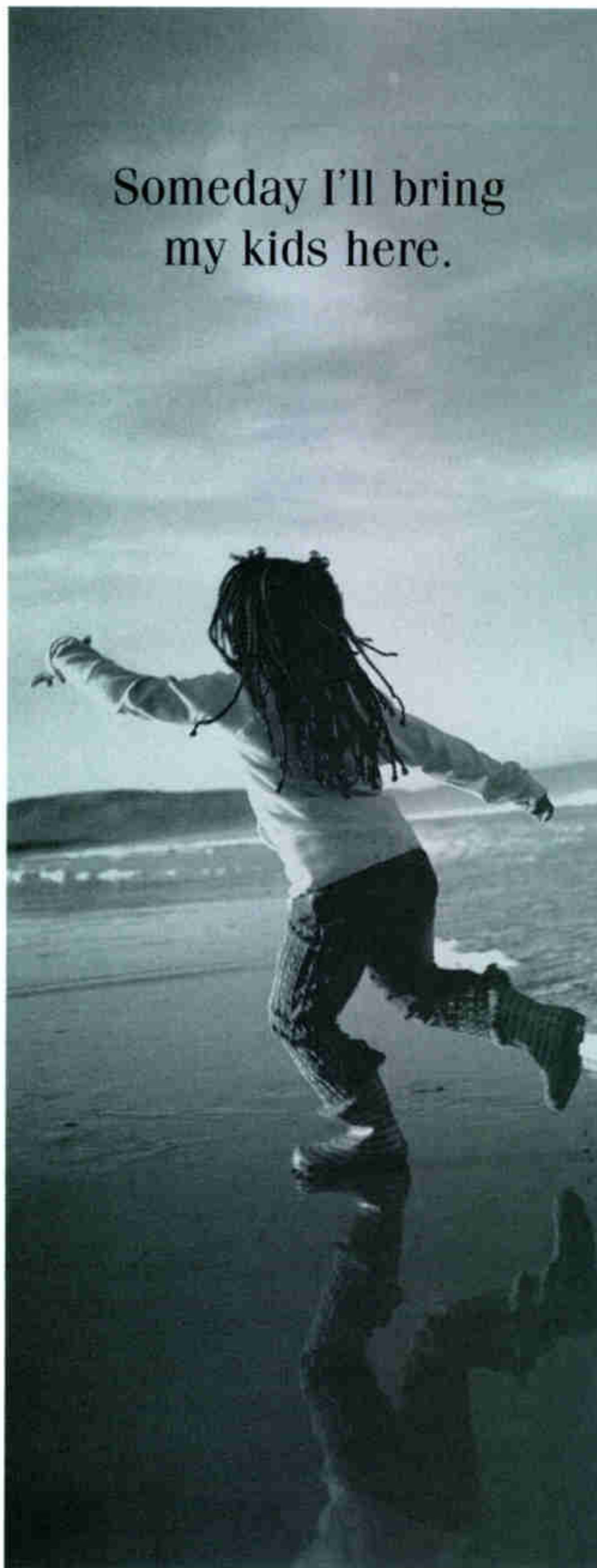
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Geographica: Europe's Baby Bust

Europe should be held up as a shining example for the rest of the world. I'm embarrassed that the U.S. still has such a high birthrate. Europeans have obviously figured out that there are many benefits to couples having only one child—or none—as opposed to the financial, social, and environmental drawbacks of having multiple children. I don't feel bad for governments that won't be able to generate enough taxes. Fewer people on the planet means a better quality of life for everyone. Governments will have to adapt.

JOELLE PEEBLES
Santa Rosa, California

Isn't any decrease in world population a good thing from an environmental point of view?

Parts of Europe are severely deforested and polluted, and more are overcrowded. But your article only mentions the inconvenience Europeans will suffer when their pensions don't materialize.

REBECCA TAPLEY
Somerville, Massachusetts

If it is true that "the world's population could decline by the end of this century," then it should be comforting to know it will be the result of a lifestyle change of choice rather than epidemic. Europe may lose tax revenue, but the alternative is much more grim.

ANGELA LUCAS
Campbell, California

I couldn't help but be struck by an incongruity in this issue: In one article you imply the



Projected population change, 2000-2050
 -20% or more -10 to 0%
 -20 to -10% Population gain

decreasing population of European countries is a bad thing for the future, while in the article on Gabon the writer points out that Gabon's forests are being logged to supply western Europe.

BILL O'DONNELL
Winona, Missouri

NG MAPS; SOURCE: UNITED NATIONS POPULATION DIVISION

Given the global significance of your article describing the inhuman treatment of human beings by 21st-century slave traders and others, why, oh why, did you not feature it on the cover? Aren't people more important than zebras?

SHERRI MAYER SWIMAN
West Roxbury, Massachusetts

I want to thank you for the discretion exercised in your September issue. Though I plan to introduce my children to the subject of slavery, I appreciate

not having it placarded on the front cover. You have allowed me the chance to thoughtfully introduce it when they are ready to understand this horror.

CRAIG C. CAPEN
Auburn Hills, Michigan

Zebras weren't on the cover of every issue. Copies of the September issue sold in the United Kingdom—as well as many of our local-language editions—had the slavery story on the cover.

Inhuman Profit

I was upset to see that the only mention of adoption in this story was a reference to the illegal adoption of Guatemalan children. My family adopted Sierra, a beautiful 16-month-old girl, from Guatemala in 2002. The legal process, while not perfect, has many checks and

balances to ensure babies are not stolen from birth mothers. Sierra's 13-year-old birth mother had DNA testing, participated in numerous interviews, and signed off on the final adoption decree. Because she was a minor, her mother also had to consent to everything. All babies adopted from Guatemala into the U.S. have to clear similar hurdles, making illegal adoptions the exception rather than the rule.

CINDY MOSES
President, Guatemala Adoptive Families of Kansas City

U.S. citizens cannot adopt children from any country that does not enforce stringent legal controls. These controls can fail in the U.S. and elsewhere. According to the Bureau of Citizenship and Immigration Services (formerly INS), UNICEF, the U.S. Department of

WRITE TO FORUM
 National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199, or by fax to 202-828-5460, or via the Internet to ngsforum@nationalgeographic.com. Include name, address, and daytime telephone. Letters may be edited for clarity and length.



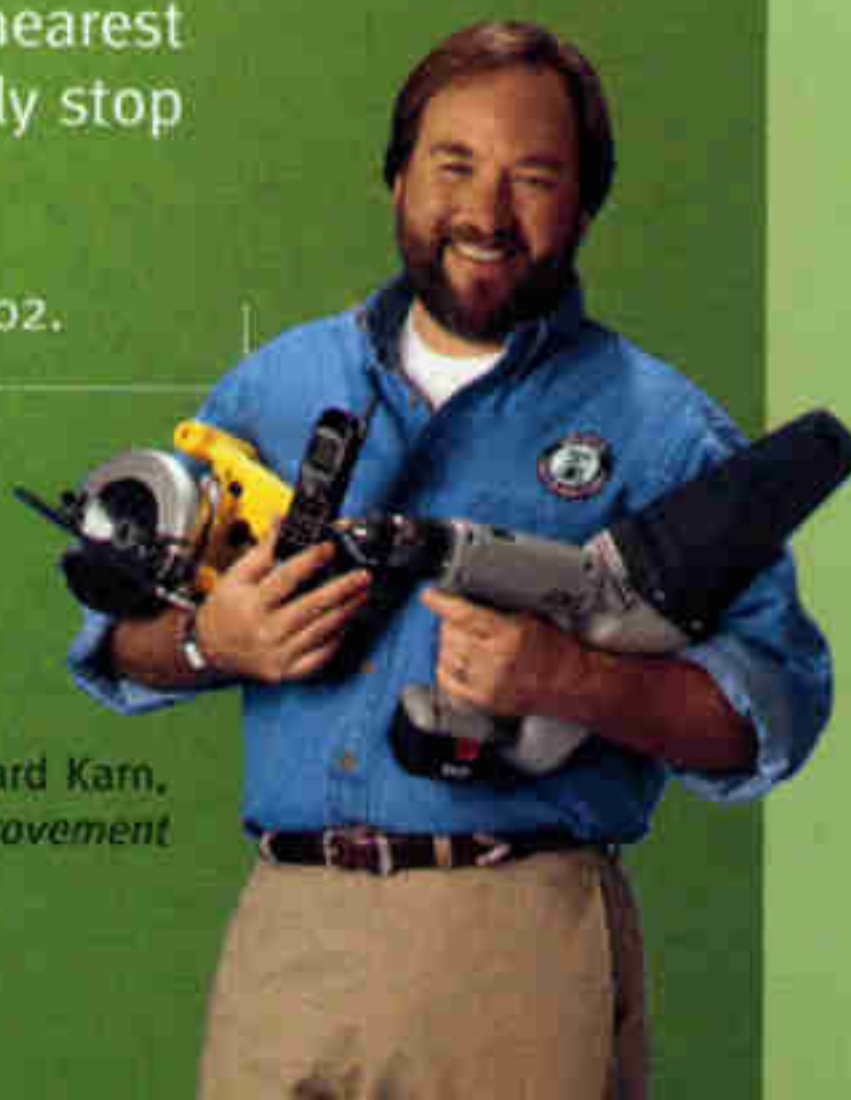
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RBRC Spokesperson Richard Karn,
"Al" from TV's *Home Improvement*



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The Sony Store
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State, and various other organizations that study and monitor international adoption, about 5 percent of international adoptions, including those from Guatemala, come from questionable sources.

Diary of a War

The picture on pages 104-105 titled "March 29: Raw Ritual" really brought home to me the human toll of wars. The feet of the little girl being prepared for burial could have been the feet of my own daughter. Thank you for bringing the real face of war to those of us who see only the polished images presented on the evening news.

KATHY BOND
Liberty, Missouri

Even though the subject is striking, the picture of the women preparing to bathe the body of a young girl before burial is invasive. While it's crucial for the world to see how the war affects the innocent, I couldn't help but wonder how those women felt while a photographer chronicled their suffering. I understand that the photographer, Alexandra Boulat, was trying to be sensitive to their pain in this composition, but should we not leave them be?

KARRYN RANSOM
Vancouver, British Columbia

Shall I save my September 2003 issue in hopes it will become a collector's item? The photo on pages 102-103 appears to be printed backward (note the clock and the writing on the young boy's shirt). Was that artistic license or an accident?

LENISE COOK
Garden Grove, California

Actually, neither. The clock and the boy's shirt are reflections in a mirror. You can see the mirror's frame just above the clock.

Saving Africa's Eden

Bravo for such an extensive exploration of Gabon and its new national park system. It gives me, a former Peace Corps volunteer who lived and worked near the new Plateaux Batéké National Park, hope that the world is finally realizing the

My village in southern Sudan was raided by northern Sudanese militiamen, who killed indiscriminately, capturing women and children. Most of my family died that day, but I was spared, only to become a slave.

importance of Gabon's diversity. Mike Fay's unorthodox approach to exploration and conservation has certainly garnered needed attention to this African Eden. For too long the West has focused on negatives such as deforestation, dwindling habitat, and the increasing bushmeat trade. I applaud President Bongo for taking initiative to try to ensure a legacy of environmental conservation for future generations.

CAROL STANLEY-YOMBI
Durham, North Carolina

Was the mention of the American government's financial contribution to this grand project designed as a feel-good pep pill?

To this reader it is a very bitter pill when taken in its proper context. On one hand, the U.S. says no thanks to the Kyoto agreement, then it goes on to contribute a pittance to the grand Gabon multiple parks plan. Reading between the lines, the U.S. appears to be saying that, yes, the environment is very important but do not expect us—its greatest polluters—to sacrifice our luxurious lifestyle.

JIM ROELOFS
Wodonga, Victoria

Geographica: Fatal Attraction

The problem of bird collisions with windows is not limited to Toronto. Since 1978 volunteers in New York and Chicago have found 31,400 birds of 147 different species that were killed or injured in this way. Nor is the problem limited to major cities. It occurs at picture windows and office parks—wherever birds and glass coexist. Window strikes are a major yet overlooked threat to migratory bird populations, many of which are in decline. We need to focus the best minds in the fields of architecture, glass engineering, and landscape design on developing creative solutions to this conservation challenge. Otherwise, many of today's most beloved birds will just be empty names to our grandchildren.

MARCIA FOWLE
President, New York City Audubon Society
KENNETH R. WYSOCKI
President, Chicago Ornithological Society

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MIDDLE EAST

Very Long Division

The West Bank barrier—an answer from another age

Walls have a long pedigree in the Holy Land. Ancient Jericho was famous for its wall, and Jerusalem's Old City is still encircled by a stone structure whose foundation dates back centuries. Over time, it has helped stop, or at least slow, onrushing armies of Seljuks, Crusaders, and Mongols. From the centuries-old Great Wall of China to the short-lived Berlin Wall, barriers have long insulated tribes, cities, even civilizations, demarcating "us" on the inside from "them" on the outside.

By historic standards, the new West Bank wall is a little different. The Israeli government hopes it will keep "them"—in this case Palestinians, and specifically those bent on terrorism—at bay by encircling Palestinian towns and villages.

Roughly 300 feet wide in some stretches, the barrier includes mounds of razor wire and electronic fencing; a ditch to prevent vehicles from crashing through; a ribbon of sand to preserve the footprints of intruders; locked gates, which Israeli soldiers can open to provide limited passage; and a network of motion detectors and surveillance cameras. In a few areas, concrete partitions (above), not fencing, are being used to prevent Palestinian sniper attacks.

While only 87 miles of the barrier have been built—at an estimated cost of four million



ED KASHI (BOTH)

Concrete slabs 25 feet high are part of the barrier around Qalqilyah, home to 40,000 Palestinians. The only way in or out: through an Israeli checkpoint.

dollars a mile—it is already taking a toll by separating farmers from their fields. On a recent day in Zayta (left), Palestinians heading home from their olive groves waited two hours for an Israeli soldier to unlock a gate. Finally, one frustrated father led his family over the fence. In Turah al Gharbiyah, the wall cut off Nael Salah Zeid's house from his village and from basic utilities. "It's like living in a jail," he says, "but even prisoners have water and electricity. We don't."

Fearing for their own lives, roughly 80 percent of Israeli Jews support the fence. "I wasn't afraid five years ago," says Inbal Omer, 30, a mother of two in the settlement of Shaqed. But then the suicide bombings resumed. Relations with local Palestinians, once sweet, soured. And Inbal's best friend was killed in a





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ED KASHI

choke the economy with checkpoints, like one in Bartaa (above); and destroy the West Bank's territorial continuity.

One potential consequence of the wall: It could fragment the Palestinians so much that it saps their aspirations for statehood. Even at this early stage of wall building, an estimated 30 percent of them say that, if they can't achieve independence, they want to be an integral part of Israel—a voting part. Because Palestinians are expected to outnumber Israelis in less than twenty years, that means the Jewish state could one day vanish in a hail not of bullets but of ballots. —Alan Mairson

Other Beefed-up Borders

- India-Pakistan** India has been building an 1,800-mile-long fence to keep out Pakistani militants.
- Kuwait-Iraq** Kuwait has built 150 miles of border fences and berms.
- North Korea-South Korea** Two barbed-wire barriers sandwich the 2.5-mile-by-148-mile Demilitarized Zone separating the countries.
- United States-Mexico** Roughly 60 miles of fence aims to keep illegal immigrants out of California.
- Zambia-Angola** Zambia is building a 620-mile border fence to keep out sick cattle from Angola.
- Cyprus** A 112-mile fence separates the Turkish from the Greek side.

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terrorist attack. "There has to be a separation," she says. "The fence makes me more secure."

But it is the expansion of Israel's West Bank settlements, not security, that truly explains the course of the wall, argues Anwar Al Darkazally, a lawyer for the Palestine Liberation Organization. By

building a wall around Israeli settlements, he says, Israel is grabbing land inside the Green Line—the boundary between Israel and the West Bank (based on the 1949 armistice line between Israel and the then Jordanian-occupied West Bank). The wall, Darkazally adds, will isolate Palestinians; further

EMERGING EXPLORER ZERESENAY "ZERAY" ALEMSEGED Sifting through earth—and time—under the relentless sun of Ethiopia's Afar region, paleontologist Zeray Alemseged is exploring the Dikika paleoanthropological site. The clues he and his team discover about humans over the past four million years will shed new light on a critical juncture in human evolution. Patiently coaxing secrets from the past, his dawn-to-dark work is conducted in one of the most remote and challenging corners of the world, where the first vehicle ever to arrive was Zeray's own.



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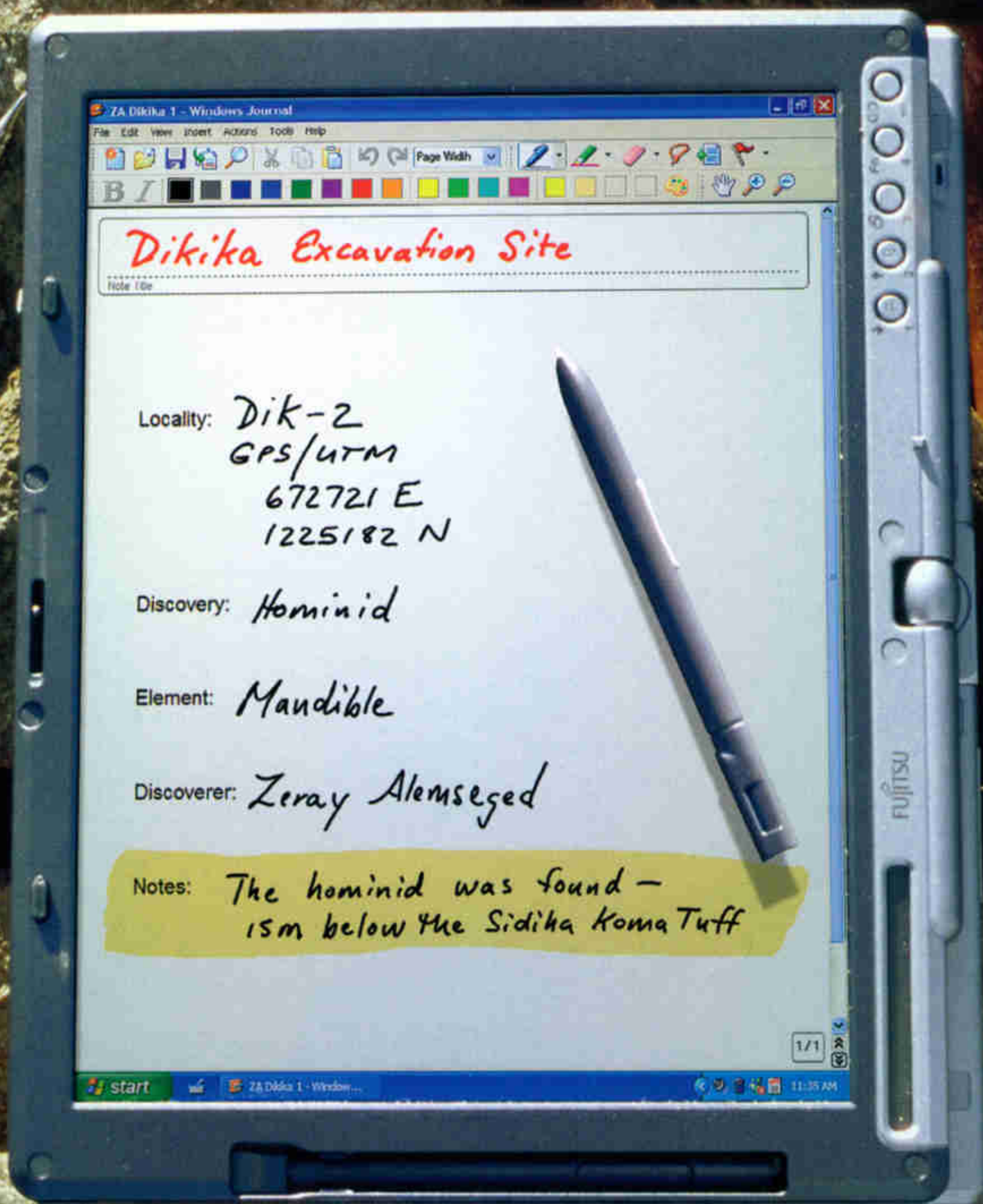
*—Zeray Alemseged, Paleontologist,
Institute of Human Origins at
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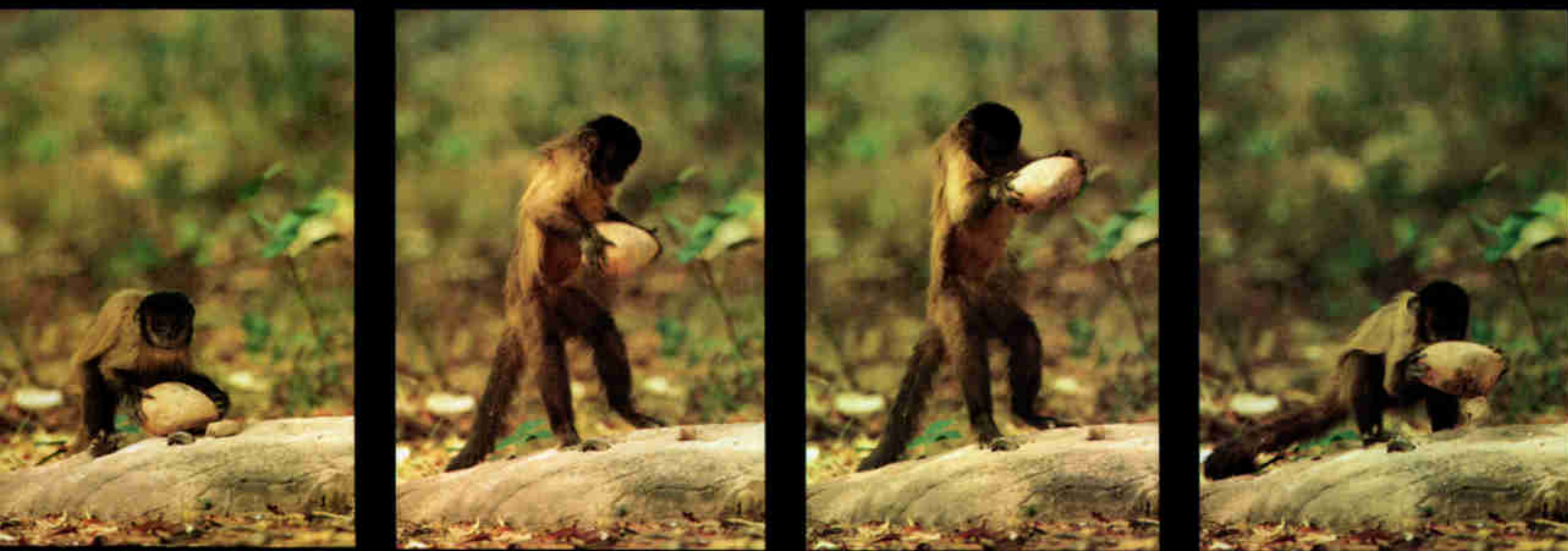
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PETE OXFORD, MINDEN PICTURES

ANIMAL BEHAVIOR

Tool Time, Monkey Style

No nut's too tough for rock-wielding capuchins

Tool use was once touted as a key thing that separates human from beast. But in truth, lots of other animals use tools, from apes to birds to bugs. Recently scientists caught a glimpse of wild monkeys using tools in a surprisingly sophisticated way.

The monkeys, brown capuchins (*Cebus apella*), tool around in a remote dry forest in northeastern Brazil. After laying tough-shelled palm nuts on sandstone slabs, the monkeys stand up—sometimes using their tails for support—raise rocks perhaps half their own weight head high, then slam the nuts (above). Not content with any old hammer, the monkeys will haul a favorite rock to the “anvil” site, says photographer Pete Oxford. They also place nuts in small pits from previous hammering and sniff them between strikes to see if the kernel is exposed yet. Older capuchins are the best nut crackers, but young ones also try their hand.

“These monkeys are acting in ways we once thought only apes did,” says primatologist Dorothy Fragaszy of the University of

Georgia, who plans to study the monkeys’ tool use in detail. And since capuchins are only distantly related to apes, she says, their ability must have evolved independently.

“Their Schwarzenegger dead lift is amazing to see,” says Charles Munn, a zoologist with Tropical Nature (a nonprofit ecotourism group) who first learned of the hammer wielders from locals. “But it’s no surprise the monkeys have to work hard to get food in such a marginal, scrubby habitat.”

—Jennifer Steinberg Holland

Tool Kit for the Birds

Primates aren’t alone in their tool-using talents:

Tree probers The Galápagos woodpecker finch uses twigs or cactus spines to probe holes in trees where insect larvae hide.

Egg breakers Egyptian vultures hurl stones at ostrich eggs to crack them open for a meal.

WEBSITE EXCLUSIVE

Watch a video clip of capuchins smashing nuts with rock tools at nationalgeographic.com/magazine/resources/0401.

LAST CALL

Back to Nature

It was paradise—except for its stockpile of deadly chemicals. Now the chemicals are gone, as are most of its residents (some 1,200 in recent years). Johnston Atoll, 825 miles southwest of Honolulu, once served as a U.S. base and nuclear test site (below). In the 1970s its remoteness and lack of native population sealed its fate as a storage depot for sarin, Agent Orange, and more. Acting on a 1985 congressional order, the Army completed destruction of four million pounds of chemicals in 2001. All but a handful of Air Force staffers are scheduled to leave by this month; most civilians have already gone. Now Johnston has only one status: wildlife refuge.

—Margaret G. Zackowitz



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The World's Best Diving Spots

David Doubilet *Contributing Photographer-in-Residence*

It's the question everyone asks one of the world's great underwater photographers: What's your favorite dive spot? Even after nearly 60 GEOGRAPHIC stories, David still has a hard time choosing. "Besides, people ask for different reasons," he says. "If you're looking for a romantic honeymoon dive spot, go to Bora Bora."

1 The reefs of Milne Bay, Papua New Guinea

There's a warm patch of water in the western Pacific that nurtures the richest coral reef systems in the world; Milne Bay is its unspoiled corner. Indonesia is in the same zone, but PNG doesn't have Indonesia's crushing population.

2 Tasmania Everything's different here, from the bizarre sea-dragons to the brooding forests that press against the Tasman Sea. Cold, plankton-rich waters well up along the island's east coast, attracting deep-sea creatures to the shallows.



JENNIFER HAYES (TOP); DAVID DOUBILET (ABOVE AND BOTTOM)

3 Hopkins Island, South Australia Most sea lions are like psychotic torpedoes, but the Australian sea lions here (above) are like golden retrievers: smart, funny, creative—the most wonderful sea lions I've ever dived with.

4 The South African coast Great white sharks, yes, but much more. When the sardines run, they bring seals, dolphins, and other predators. To me,

this is the most exciting dive in the world.

5 The northern Red Sea It's been "discovered," but my feelings for the place run deep: This is where I shot some of my first pictures for GEOGRAPHIC (November 1972).

6 Bali, Indonesia The dark, volcanic sand off the northeast coast gives Bali's colorful creatures a perfect backdrop (left).

7 North Sound, Grand Cayman The sandbars, clear water, and stingrays here always bring me a great sense of peace. Sure, hundreds of divers come every day, but the tourist boats don't stick around long. Stay the whole day, then watch the light change.

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What are your own favorite diving and snorkeling spots? Share them in our Forum at nationalgeographic.com/magazine/0401.



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TODAY

TOMORROW

TOYOTA

Do It Yourself

MARS (SEE PAGE 2)



PASCAL LEE, NASA HAUGHTON-MARS PROJECT 2001

GO THERE

Mars on Earth

You may not be able to travel to Mars, but there are places on Earth that share enough features, either climatic (cold and dry) or geologic (volcanoes, impact craters), to serve as stand-ins for the red planet.

■ **Devon Island** in the Canadian Arctic (above) boasts a large impact crater—and by happy chance it's in a polar desert. Mars scientists and members of the nongovernmental Mars Society travel here every summer to study the environment and simulate Mars exploration.

■ **Antarctica's Dry Valleys** offer a 1,500-square-mile, ice-free patch on the frozen continent. They're so dry and cold that some lichens and bacteria are forced to live inside rocks, a niche that may also support life on Mars.

■ **Mauna Loa** on Hawaii's Big Island, the largest volcano on Earth, is a scale model of Mars's Olympus Mons, the largest volcano in the solar system. Both are shield volcanoes—broad cones with gentle slopes formed by fluid lava.

■ **Iceland** is a natural laboratory for studying the interactions of ice and volcanoes, the same forces that have shaped much of the Martian surface.

TRY IT AT HOME

Put Yourself on Martian Time

The solar-powered rovers explore during daylight, acting on instructions radioed during the night from the Jet Propulsion Laboratory in Pasadena, California. Since the average time between sunsets on Mars is 24 hours, 39 minutes, and 35 seconds, the JPL rover operators keep in sync by beginning work 40 minutes later every Earth day. Two weeks after the Spirit rover lands on January 4, rover drivers will feel a nine-time-zone jet lag. To get the current time on Mars from NASA's Goddard Institute for Space Studies, go to www.giss.nasa.gov/tools/mars24.

Sunset on Mars as recorded by NASA's Mars Pathfinder mission, 1997.

NASA/JPL

PICKS

3 reads

British science writer **Oliver Morton**, author of this month's cover story and the book *Mapping Mars: Science, Imagination, and the Birth of a World*, says his interest in Mars began when he read science fiction novels about the planet. Here he describes his favorites:

- **Red Mars** (1992), **Green Mars** (1993), and **Blue Mars** (1995), by Kim Stanley Robinson. A three-part saga that powerfully evokes the changes humans could make to Mars—and Mars could make to humans.
- **Mars Crossing**, by Geoffrey A. Landis (2000). The story of a hazardous trek across the planet. As technologically and scientifically accurate as anything yet written, and full of great details.
- **A Princess of Mars**, by Edgar Rice Burroughs (1917). Exotic cities, savage warriors, and serious swordplay—Mars as it really ought to have been, from the author of *Tarzan of the Apes*.

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Find Martian multimedia, a photo gallery, and author Oliver Morton's field notes at nationalgeographic.com/magazine/0401.



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Unlike your stomach, your esophagus offers no protection against churning acid. When acid rises into the esophagus, it can eventually wear away the lining. This condition is called erosive esophagitis and only a doctor can determine if you have it.

NEXIUM works by "turning off" many of the pumps that produce acid. Once the amount of acid has been reduced, NEXIUM can begin to heal any erosions caused by acid reflux disease. Most erosions heal in 4 to 8 weeks with NEXIUM. Your results may vary.

Talk with your health care professional to see if NEXIUM is right for you. NEXIUM has a low occurrence of side effects, including headache, diarrhea and abdominal pain. Symptom relief does not rule out serious stomach conditions.

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Please read the important Product Information about NEXIUM on the following page and discuss it with your doctor.

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(esomeprazole magnesium)

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Please read this summary carefully, and then ask your doctor about NEXIUM.

No advertisement can provide all the information needed to prescribe a drug. This advertisement does not take the place of careful discussions with your doctor. Only your doctor has the training to weigh the risks and benefits of a prescription drug for you.

Nexium® (esomeprazole magnesium) 20-MG, 40-MG Delayed-Release Capsules

BRIEF SUMMARY Before prescribing NEXIUM, please see full Prescribing Information.

INDICATIONS AND USAGE NEXIUM is indicated for the short-term treatment (4 to 8 weeks) in the healing and symptomatic resolution of diagnostically confirmed erosive esophagitis. **CONTRAINDICATIONS** NEXIUM is contraindicated in patients with known hypersensitivity to any component of the formulation or to substituted benzimidazoles.

PRECAUTIONS Symptomatic response to therapy with NEXIUM does not preclude the presence of gastric malignancy. Atrophic gastritis has been noted occasionally in gastric corpus biopsies from patients treated long-term with omeprazole, of which NEXIUM is an enantiomer.

Information for Patients: NEXIUM Delayed-Release Capsules should be taken at least one hour before meals. For patients who have difficulty swallowing capsules, one tablespoon of applesauce can be added to an empty bowl and the NEXIUM Delayed-Release Capsule opened, and the pellets carefully emptied onto the applesauce. The pellets should be mixed with the applesauce and then swallowed immediately. The applesauce used should not be hot and should be soft enough to be swallowed without chewing. The pellets should not be chewed or crushed. The pellet/applesauce mixture should not be stored for future use. Antacids may be used while taking NEXIUM. **Drug Interactions:** Esomeprazole is extensively metabolized in the liver by CYP2C19 and CYP3A4. *In vitro* and *in vivo* studies have shown that esomeprazole is not likely to inhibit CYPs 1A2, 2A6, 2C9, 2D6, 2E1 and 3A4. No clinically relevant interactions with drugs metabolized by these CYP enzymes would be expected. Drug interaction studies have shown that esomeprazole does not have any clinically significant interactions with phenytoin, warfarin, quinidine, clarithromycin or amoxicillin. Post-marketing reports of changes in prothrombin measures have been received among patients on concomitant warfarin and esomeprazole therapy. Increases in INR and prothrombin time may lead to abnormal bleeding and even death. Patients treated with proton pump inhibitors and warfarin concomitantly may need to be monitored for increases in INR and prothrombin time. Esomeprazole may potentially interfere with CYP2C19, the major esomeprazole metabolizing enzyme. Coadministration of esomeprazole 30 mg and diazepam, a CYP2C19 substrate, resulted in a 45% decrease in clearance of diazepam. Increased plasma levels of diazepam were observed 12 hours after dosing and onwards. However, at that time, the plasma levels of diazepam were below the therapeutic interval, and thus this interaction is unlikely to be of clinical relevance. Esomeprazole inhibits gastric acid secretion. Therefore, esomeprazole may interfere with the absorption of drugs where gastric pH is an important determinant of bioavailability (eg, ketoconazole, iron salts and digoxin). Coadministration of oral contraceptives, diazepam, phenytoin, or quinidine did not seem to change the pharmacokinetic profile of esomeprazole. **Carcinogenesis, Mutagenesis, Impairment of Fertility:** The carcinogenic potential of esomeprazole was assessed using omeprazole studies. In two 24-month oral carcinogenicity studies in rats, omeprazole at daily doses of 1.7, 3.4, 13.8, 44.0 and 140.8 mg/kg/day (about 0.7 to 57 times the human dose of 20 mg/day expressed on a body surface area basis) produced gastric ECL cell carcinoids in a dose-related manner in both male and female rats; the incidence of this effect was markedly higher in female rats, which had higher blood levels of omeprazole. Gastric carcinoids seldom occur in the untreated rat. In addition, ECL cell hyperplasia was present in all treated groups of both sexes. In one of these studies, female rats were treated with 13.8 mg omeprazole/kg/day (about 5.6 times the human dose on a body surface area basis) for 1 year, then followed for an additional year without the drug. No carcinoids were seen in these rats. An increased incidence of treatment-related ECL cell hyperplasia was observed at the end of 1 year (94% treated vs 10% controls). By the second year the difference between treated and control rats was much smaller (46% vs 26%) but still showed more hyperplasia in the treated group. Gastric adenocarcinoma was seen in one rat (2%). No similar tumor was seen in male or female rats treated for 2 years. For this strain of rat no similar tumor has been noted historically, but a finding involving only one tumor is difficult to interpret. A 78-week mouse carcinogenicity study of omeprazole did not show increased tumor occurrence, but the study was not conclusive. Esomeprazole was negative in the Ames mutation test, in the *in vivo* rat bone marrow cell chromosome aberration test, and the *in vivo* mouse micronucleus test. Esomeprazole, however, was positive in the *in vitro* human lymphocyte chromosome aberration test. Omeprazole was positive in the *in vitro* human lymphocyte chromosome aberration test, the *in vivo* mouse bone marrow cell chromosome aberration test, and the *in vivo* mouse micronucleus test. The potential effects of esomeprazole on fertility and reproductive performance were assessed using omeprazole studies. Omeprazole at oral doses up to 138 mg/kg/day in rats (about 56 times the human dose on a body surface area basis) was found to have no effect on reproductive performance of parental animals. **Pregnancy: Teratogenic Effects. Pregnancy Category B—**Teratology studies have been performed in rats at oral doses up to 280 mg/kg/day (about 57 times the human dose on a body surface area basis) and in rabbits at oral doses up to 86 mg/kg/day (about 35 times the human dose on a body surface area basis) and have revealed no evidence of impaired fertility or harm to the fetus due to esomeprazole. There are, however, no adequate and well-controlled studies in pregnant women. Because animal reproduction studies are not always predictive of human response, this drug should be used during pregnancy only if clearly needed. Teratology studies conducted with omeprazole in rats at oral doses up to 138 mg/kg/day (about 56 times the human dose on a body surface area basis) and in rabbits at doses up to 69 mg/kg/day (about 56 times the human dose on a body surface area basis) did not disclose any evidence for a teratogenic potential of omeprazole. In rabbits, omeprazole in a dose range of 6.9 to 69.1 mg/kg/day (about 5.5 to 56 times the human dose on a body surface area basis) produced dose-related increases in embryo-letality, fetal resorptions, and pregnancy disruptions. In rats, dose-related embryo/fetal toxicity and postnatal developmental toxicity were observed in offspring resulting from parents treated with omeprazole at 13.8 to 138.0 mg/kg/day

(about 5.6 to 56 times the human doses on a body surface area basis). There are no adequate and well-controlled studies in pregnant women. Sporadic reports have been received of congenital abnormalities occurring in infants born to women who have received omeprazole during pregnancy. **Nursing Mothers:** The excretion of esomeprazole in milk has not been studied. However, omeprazole concentrations have been measured in breast milk of a woman following oral administration of 20 mg. Because esomeprazole is likely to be excreted in human milk, because of the potential for serious adverse reactions in nursing infants from esomeprazole, and because of the potential for tumorigenicity shown for omeprazole in rat carcinogenicity studies, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the mother. **Pediatric Use:** Safety and effectiveness in pediatric patients have not been established. **Geriatric Use:** Of the total number of patients who received NEXIUM in clinical trials, 778 were 65 to 74 years of age and 124 patients were ≥ 75 years of age. No overall differences in safety and efficacy were observed between the elderly and younger individuals, and other reported clinical experience has not identified differences in responses between the elderly and younger patients, but greater sensitivity of some older individuals cannot be ruled out. **ADVERSE REACTIONS** The safety of NEXIUM was evaluated in over 10,000 patients (aged 18-84 years) in clinical trials worldwide including over 7,400 patients in the United States and over 2,600 patients in Europe and Canada. Over 2,900 patients were treated in long-term studies for up to 6-12 months. In general, NEXIUM was well tolerated in both short- and long-term clinical trials. The safety in the treatment of healing of erosive esophagitis was assessed in four randomized comparative clinical trials, which included 1,240 patients on NEXIUM 20 mg, 2,434 patients on NEXIUM 40 mg, and 3,008 patients on omeprazole 20 mg daily. The most frequently occurring adverse events ($\geq 1\%$) in all three groups was headache (5.5, 5.0, and 3.8, respectively) and diarrhea (no difference among the three groups). Nausea, flatulence, abdominal pain, constipation, and dry mouth occurred at similar rates among patients taking NEXIUM or omeprazole. Additional adverse events that were reported as possibly or probably related to NEXIUM with an incidence $< 1\%$ are listed below by body system: **Body as a Whole:** abdomen enlarged, allergic reaction, asthenia, back pain, chest pain, chest pain substernal, facial edema, peripheral edema, hot flushes, fatigue, fever, flu-like disorder, generalized edema, leg edema, malaise, pain, rigors; **Cardiovascular:** flushing, hypertension, tachycardia; **Endocrine:** goiter; **Gastrointestinal:** bowel irregularity, constipation aggravated, dyspepsia, dysphagia, dysplasia GI, epigastric pain, eructation, esophageal disorder, frequent stools, gastroenteritis, GI hemorrhage, GI symptoms not otherwise specified, hiccup, melena, mouth disorder, pharynx disorder, rectal disorder, serum gastrin increased, tongue disorder, tongue edema, ulcerative stomatitis, vomiting; **Hearing:** earache, tinnitus; **Hematologic:** anemia, anemia hypochromic, cervical lymphadenopathy, epistaxis, leukocytosis, leukopenia, thrombocytopenia; **Hepatic:** bilirubinemia, hepatic function abnormal, SGOT increased, SGPT increased; **Metabolic/Nutritional:** glycosuria, hyperuricemia, hyponatremia, increased alkaline phosphatase, thirst, vitamin B12 deficiency, weight increase, weight decrease; **Musculoskeletal:** arthralgia, arthritis aggravated, arthropathy, cramps, fibromyalgia syndrome, hernia, polymyalgia rheumatica; **Nervous System/Psychiatric:** anorexia, apathy, appetite increased, confusion, depression aggravated, dizziness, hypertonia, nervousness, hypoesthesia, impotence, insomnia, migraine, migraine aggravated, paresthesia, sleep disorder, somnolence, tremor, vertigo, visual field defect; **Reproductive:** dysmenorrhea, menstrual disorder, vaginitis; **Respiratory:** asthma aggravated, coughing, dyspnea, larynx edema, pharyngitis, rhinitis, sinusitis; **Skin and Appendages:** acne, angioedema, dermatitis, pruritus, pruritus ani, rash, rash erythematous, rash maculo-papular, skin inflammation, sweating increased, urticaria; **Special Senses:** otitis media, parosmia, taste loss, taste perversion; **Urogenital:** abnormal urine, albuminuria, cystitis, dysuria, fungal infection, hematuria, micturition frequency, moniliasis, genital moniliasis, polyuria; **Visual:** conjunctivitis, vision abnormal. Endoscopic findings that were reported as adverse events include: duodenitis, esophagitis, esophageal stricture, esophageal ulceration, esophageal varices, gastric ulcer, gastritis, hernia, benign polyps or nodules, Barrett's esophagus, and mucosal discoloration. **Postmarketing Reports** - There have been spontaneous reports of adverse events with postmarketing use of esomeprazole. These reports have included rare cases of anaphylactic reaction. Other adverse events not observed with NEXIUM, but occurring with omeprazole can be found in the omeprazole package insert, **ADVERSE REACTIONS** section. **OVER-DOSAGE** A single oral dose of esomeprazole at 510 mg/kg (about 103 times the human dose on a body surface area basis), was lethal to rats. The major signs of acute toxicity were reduced motor activity, changes in respiratory frequency, tremor, ataxia, and intermittent clonic convulsions. There have been some reports of overdosage with esomeprazole. Reports have been received of overdosage with omeprazole in humans. Doses ranged up to 2,400 mg (120 times the usual recommended clinical dose). Manifestations were variable, but included confusion, drowsiness, blurred vision, tachycardia, nausea, diaphoresis, flushing, headache, dry mouth, and other adverse reactions similar to those seen in normal clinical experience (see omeprazole package insert-**ADVERSE REACTIONS**). No specific antidote for esomeprazole is known. Since esomeprazole is extensively protein bound, it is not expected to be removed by dialysis. In the event of overdosage, treatment should be symptomatic and supportive. As with the management of any overdose, the possibility of multiple drug ingestion should be considered. For current information on treatment of any drug overdose, a certified Regional Poison Control Center should be contacted. Telephone numbers are listed in the Physicians' Desk Reference (PDR) or local telephone book.

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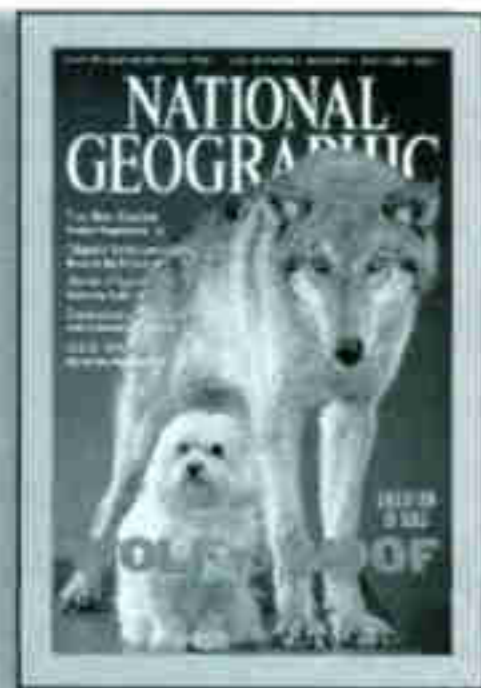
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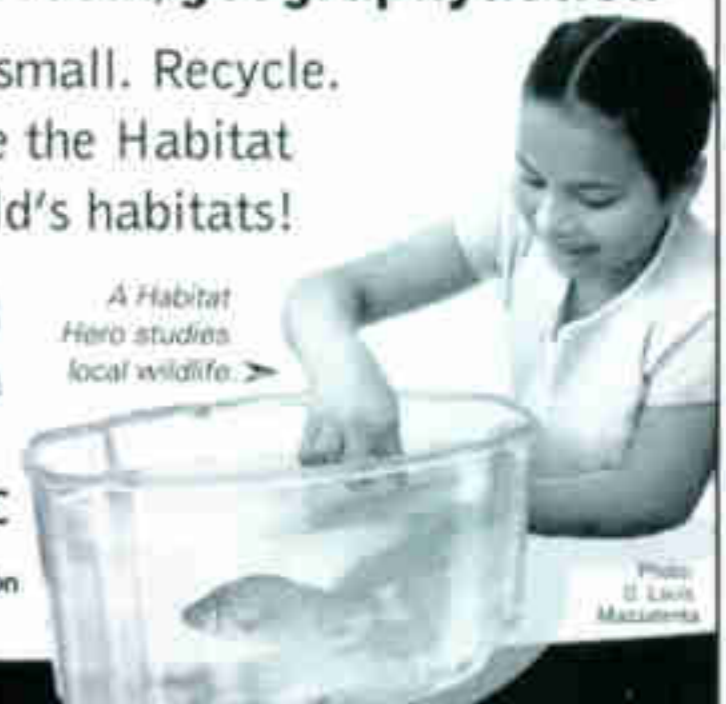


Photo: U. Lwin/Magnum

Behind
the

SCENES

AT THE NATIONAL GEOGRAPHIC SOCIETY



Animal Photographers

NG Channel's Crittercam show goes wild

She prowls. She stalks. She feeds. All the while, the Crittercam collar around her neck records the world as she sees it. And Leila the lion (above) seems to be oblivious to the strange necklace she's wearing. "That gives us confidence we'll witness natural behavior," says Greg Marshall. A biologist and filmmaker, Greg created the



JEFF HUTCHENS, NGCI (TOP); NGT&F REMOTE IMAGING

device 17 years ago, originally as a way for scientists to observe the behavior of sea creatures they couldn't record firsthand. Crittercam records depth, light level, and temperature as well as image and sound.

"I always thought that with land animals you could just pick up binoculars and observe them," says Greg. But he learned that getting close enough to watch them with binoculars can affect their behavior. So now Greg and his team are putting Crittercams on hyenas, cats, even grizzly bears, research that will be featured on National Geographic Channel's new series *Crittercam*, airing Saturdays at 8 p.m. ET/PT, beginning January 17.

Leila the lion shot the test run

for the terrestrial Crittercam, recording footage of a cub taking a prowling at night (below) and a pride of lions feeding on a kill—and that's just the beginning.

Caught on Crittercam

Hawaiian monk seals hunt in deep waters as well as in protected atolls.

Seals, whales, and dolphins relax when diving, enabling them to reduce oxygen consumption and to descend deeper and stay down longer.

Male leatherback turtles attempt to mate with females just coming off nesting beaches.

Emperor penguins, when hunting, dive below their prey so they can look up and see the fish in silhouette against the sea ice before rocketing in for the kill.

Tiger sharks systematically move between the ocean surface and the floor to forage.

Expanding View

Buddhist nuns of Hanle meet Mars and cars

The nuns of the Tashi Choeling convent in the Himalayan valley of Hanle were startled when photographer Mattias Klum, his two assistants, and an interpreter arrived in a 4WD vehicle.

"They opened the convent door, saw us, and slammed the door shut again," Mattias recalls. Fortunately, the interpreter was able to convince the nuns to let the visitors in. "To the nuns, we

were like something from another planet," Mattias says. "They hadn't had much contact with the West. I've rarely seen so many terrified faces."

He wanted to make certain the nuns, who live in near solitude, understood the purpose of his visit: simply to photograph the isolated Hanle Valley featured in this issue. So he brought out copies of previous NATIONAL GEOGRAPHICS with his work in them. He also showed them something truly from another planet: 3-D pictures of Mars, revealed in the August 1998 GEOGRAPHIC along with 3-D glasses to help readers see the



MATTIAS KLUM

images. "They were interested in that," Mattias reports. "But what really blew them away was an advertisement for a car. It was so strange and beautiful to them."



NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN

Beam Me Over

Our mosaic of the Mars feature Valles Marineris, the largest such image ever made (see page 2), was nearly eclipsed. When the Mars camera team at Arizona State University went to the arena to set up and photograph 402 images taken from the Mars Odyssey orbiter, they noticed a speaker in the way, high above. So team member Tara Fisher, an avid rock climber, volunteered. Belayed by her husband, Joel, she calmly climbed out on the beams and moved the speaker. Says NGM photo editor Kurt Mutchler, "We couldn't have made the picture without them."

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ARCTIC OCEAN EXPLORATION (PAGE 100)

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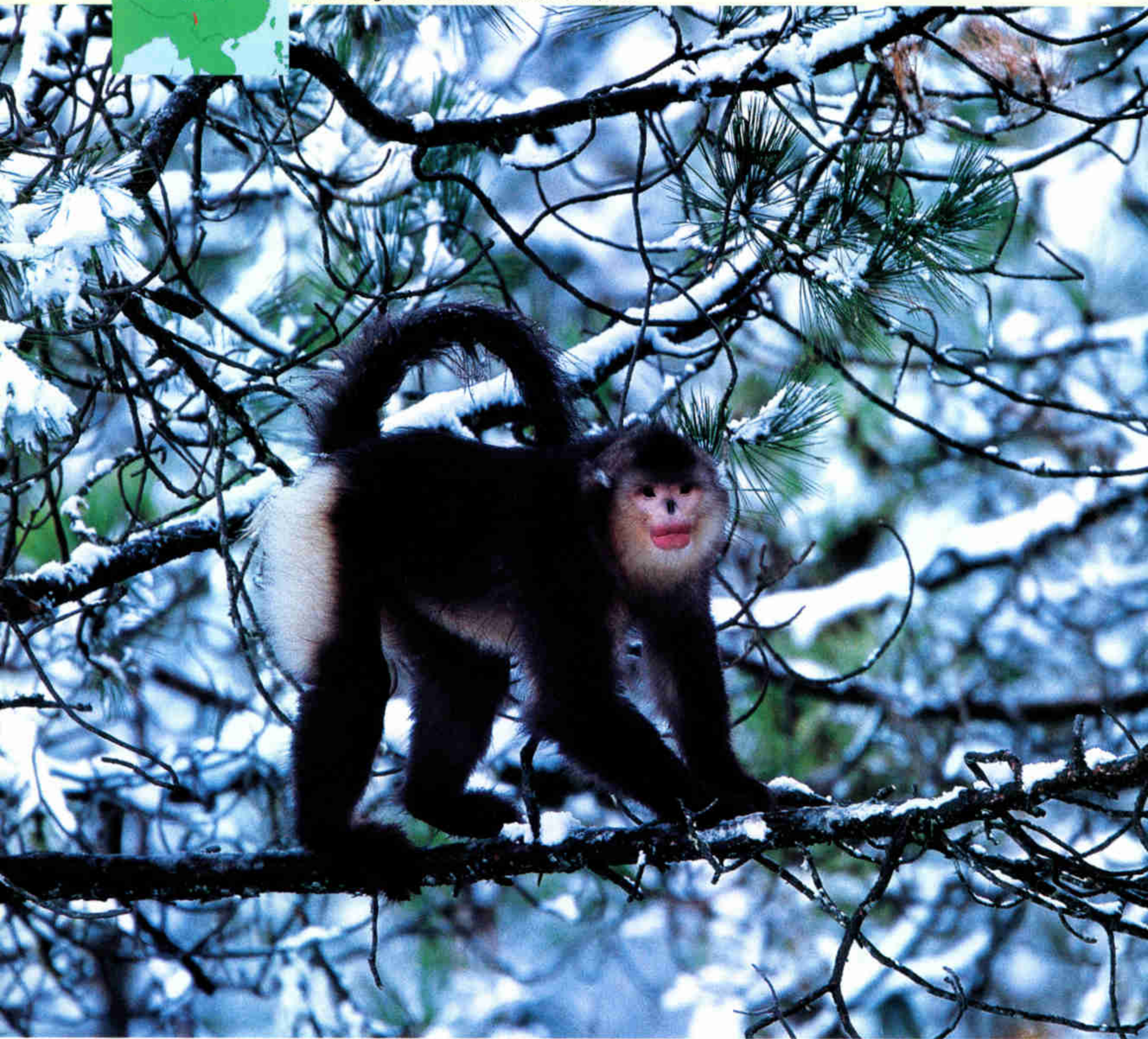


Black Snub-nosed Monkey (*Rhinopithecus bieti*)

Size: Head and body length 74-83 cm; tail 51-72 cm **Weight:** Males average 15-17 kg; females average 9-12 kg

Habitat: High mountain forests up to 4,500 meters in the Nujiang Lancang Gorge region of China

Surviving number: Estimated at 800-1,200



Photographed by Zhirong Xi

WILDLIFE AS CANON SEES IT

Up, up and away! The black snub-nosed monkey takes heights to the extreme. Not only is it at home high in the forest canopy, but it also lives at the highest elevations of any non-human primate. While monkeys most commonly live near sea level, this striking creature ranges up to 4,500 meters higher. At such heights, lichen is its most attractive food source, a staple it supplements with leaves, grass and fruit. This highland monkey's pelt was once

believed to ward off rheumatism, making it an attractive target for hunters. The biggest threat facing it today is not hunting, however, but habitat loss due to logging and general human encroachment.

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Who Knew?

COGNITION

Monkey See, Monkey Recognize

What are animals thinking?

Philosopher Thomas Nagel once asked, "What is it like to be a bat?" Is there "something that it is like to be a bat"? Well, we can try to imagine it. It's dark. We hear a lot of squeaking. We flit. We echolocate up a storm. We feel a little bit . . . batty.

But wait: Does the bat have any sense of its batness? For that matter, what's going on in the mind of a dog, a cow, an ape? Are animals self-aware?

One day in the 1960s, while shaving in front of a mirror, psychologist Gordon Gallup wondered what would happen if you put animals in front of a looking glass. He created what he called the mark test, in which primates already familiar with mirrors and their own reflection were anesthetized and marked with an odorless dye above an eyebrow and on an ear. When the animals woke up, they were shown their reflection in the mirror.

Two species, chimpanzees and orangutans, reacted by touching the dyed spots—evidence, Gallup argued, that these species are self-aware. But Donald Griffin, a biologist at Harvard University, thinks other species are also self-aware, even if they haven't passed the mark test. It doesn't make sense, says Griffin, that chimps and orangs succeed at the test, while other apes, like gorillas, do not. Besides, only 75 percent of

adult chimps pass the test. "You'd have to say that some chimps are self-aware and others aren't, which seems a bit ridiculous," Griffin says.

Some researchers contend that dolphins can pass a variation of Gallup's mark test (it's tricky when all the animal has to work with is a flipper). Hardly anything in this field is free of controversy. The stakes are high: At issue is the degree to which humans are different from other creatures. Are we special, or just . . . conceited?

Daniel Povinelli, a cognitive scientist at the University of Louisiana, argues that even small children who pass the mark test lack the kind of self-awareness that older children have. In one of Povinelli's experiments, kids watch a video of someone surreptitiously placing a large, brightly colored sticker on top of their heads just minutes earlier. Most three-year-olds, upon seeing the video, fail to reach up and remove the sticker. They recognize themselves ("That's me!") but don't quite grasp that the sticker is still on their heads ("That sticker's on *his* head"). And yet most four-year-olds pass the test.

It's hard to say for certain what the mark test really measures. Research on consciousness and self-awareness is dogged by ambiguity. Is it possible that some animals, for example, fail the test simply because they lack the motor skills to touch the mark?

Sometimes in science we get interesting answers—but can't quite decide what it was that we asked.

—Joel Achenbach

WASHINGTON POST STAFF WRITER

IT MATTERS

Show a chimp a mirror, and it'll likely recognize itself.

Show a person a mirror, and she may use it to explore the universe. The 200-inch mirror in the Hale reflecting telescope at California's Palomar Observatory was made from the biggest piece of glass ever cast at that time (see it in this month's Flashback). This mirror matters: The Hale Telescope can detect objects billions of light-years from Earth, and for more than half a century it has helped scientists stretch our understanding of how big the universe really is. Development of the telescope, which began in 1928 with a six-million-dollar grant, took 21 years. Maybe it's not self-awareness that makes humans different from other animals—maybe it's the enormous effort we make just to satisfy our curiosity.

—Lynne Warren

WEBSITE EXCLUSIVE

Learn about animal cognition—and find links to Joel Achenbach's work—at nationalgeographic.com/magazine/resources/0401.



ARIZONA STATE

SUN DEVILS





MARS ON EARTH

In unprecedented scope and detail, the largest ever image of Mars shows a 3,300-kilometer stretch (2,050 miles) of Valles Marineris—at 4,000 kilometers long, the solar system's largest canyon. With help from students and staff, Arizona State University geologist Philip Christensen (in yellow) used the school's basketball court as a backdrop to assemble this mosaic of 402 infrared images. The Thermal Emission Imaging System (THEMIS) on the Mars Odyssey orbiter captured the canyon from an altitude of about 400 kilometers with enough resolution to show features just 100 meters across. (Black areas are sections of the surface that have yet to be photographed.)

MARK THIESSEN, NGS; MARS IMAGE: NOEL GORELICK AND JAYME HARRIS, ARIZONA STATE UNIVERSITY (ASU); NASA/JPL

Ned Wulck Court



X



planet

m a r s

ice

It's not news that icecaps cling to the Martian poles. But now scientists believe that ice encrusted much of Mars in the recent past. What's more, astonishing images from two orbiters show present-day signs of remnant snowpacks and glaciers. With landers preparing to explore the planet's surface, what other surprises await?

BY OLIVER MORTON

TIMOTHY GLOTCH, ASU; NASA/JPL
100 KM x 170 KM





WHITE PLANET

Snow and ice grip the landscape around Holden crater, at top, in Mars's southern hemisphere in this blend of art and reality. Artist Kees Veenenbos draped wintry white over topographic data from the laser altimeter on the Mars Global Surveyor (MGS) orbiter to simulate how the planet might have looked 50,000 to 500,000 years ago. "If you'd viewed Mars then, you would have called it the white planet," says Phil Christensen. Scientists have begun to find dusty snowpacks and other evidence of an icier past far from the poles, which could help pinpoint where liquid water—even life—might exist today.

Aram Chaos crater (overleaf) once was underlain with water ice and deeper down, liquid water. After a violent eruption water gushed out, and the ground collapsed in complex shapes.

It's dustier than the road to death, drier than Dorothy Parker's martini, colder than the devil's kiss. Like much of Mars, the butterscotch plain is inhospitable, empty, ancient, and, when it comes down to it, pretty dull. But a few hundred meters to the south, over a shoal of low, uneven hummocks, the landscape changes. The hummocks reach a crest that curves smoothly to the east and rises sharply to the southwest. Beyond it the land falls away in a steep slope. This is the rim of a crater. Its floor—some 800 meters below—is ridged and rippled in strange, concentric forms. It looks like ground within which something has recently stirred. Or is still stirring.

And there is more evidence of movement: A smooth layer that once covered the slope has come loose and crept toward the rippled floor. Roundheaded gullies slice into that same smooth layer, while strange tongues of who-knows-what lap at the slopes beneath them.

Landscapes like this are changing the way geologists look at Mars. They've long been fascinated by the planet's distant past. Now they're getting ever more excited by the mysterious processes shaping its present—thanks in large part to the planet's apparent iciness. Martian ice is not a novelty in itself; for years geologists have expected to find it frozen into the soil at mid and high latitudes. The excitement comes from a growing suspicion that the ice doesn't just sit there but has a dynamic role to play. That it moves from place to place around the globe. That it reshapes the textures of the surface. And that it may sometimes produce fleeting traces of liquid water.

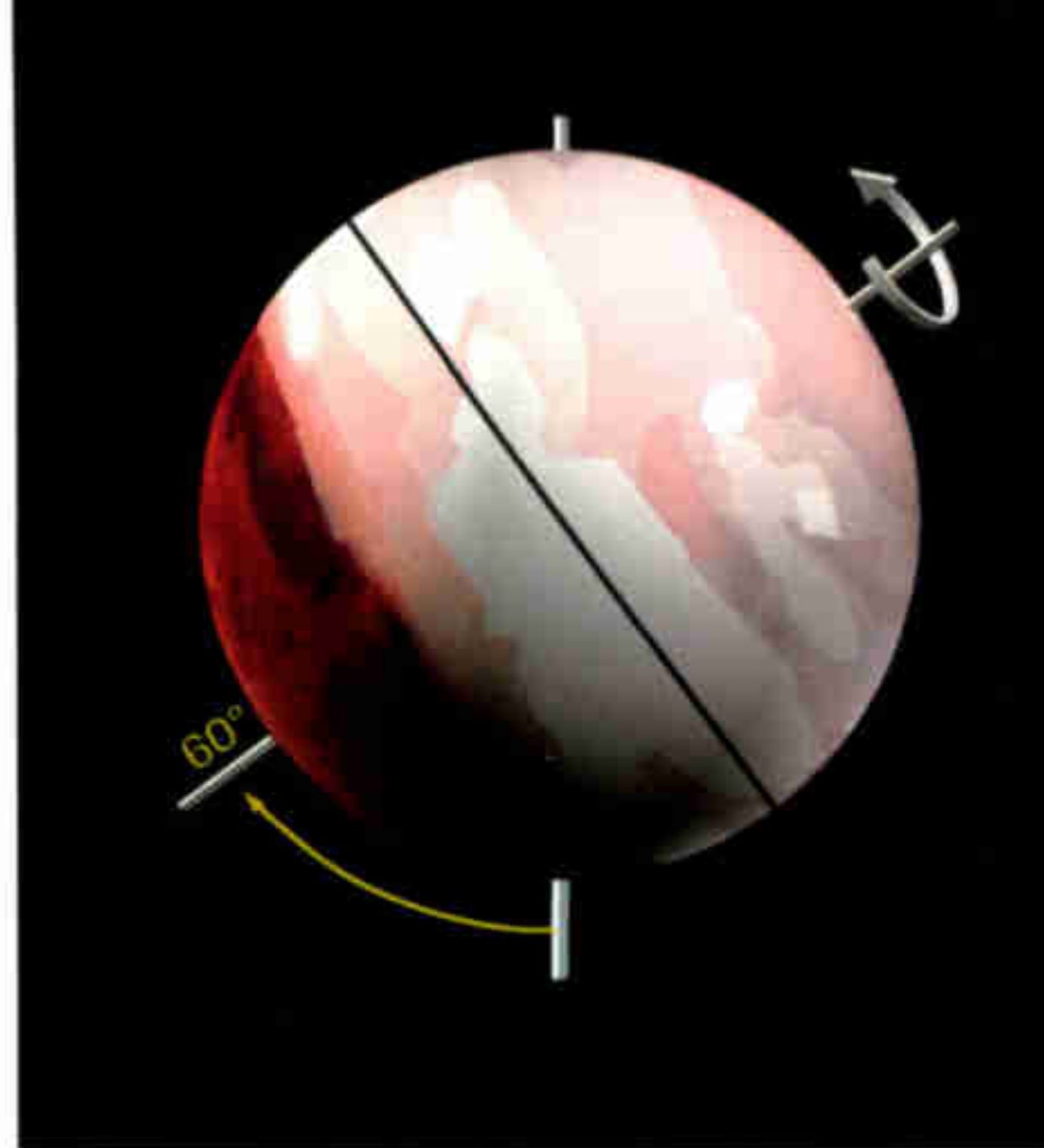
According to this view, the smooth drapery slumping into the crater is dirty ice, or possibly very icy dirt, that flows like an earthly glacier. If you could clamber a few hundred meters around the slope, or bounce down it like a low-gravity scree walker, you could find out for yourself. If you had the right instruments, a little bit of that layer could teach you a lot about Mars. You could scoop out the ice and hold it in your hands. You could watch as it vaporized into the bitterly cold, terribly thin air.

But for now the closest anything or anyone from Earth can get to this tantalizing landscape in Mars's southern highlands is when one of the

growing fleet of spacecraft orbiting the planet passes some 400 kilometers (250 miles) overhead. Three spacecraft are scheduled to land on Mars—one on December 25, 2003, and two others to follow this month—but they're headed for very different destinations. The first craft, the British-led Beagle 2, piggybacked on Europe's Mars Express orbiter, will hunt for chemical signs of past—or even present—life in the soil and atmosphere. Two rovers sent by NASA, Spirit and Opportunity, will mount small-scale geologic surveys of sites that may bear traces of water billions of years old.

The overarching theme of NASA's current Mars exploration is "follow the water," because where there is water, there might possibly be life. The landers will carry out that mission, but to achieve any of their scientific goals, the spacecraft have to land safely. With almost no ability to maneuver as they descend through the atmosphere, the craft must be aimed toward smooth, flat landing sites the size of small countries. And because the landers need warmth and use solar power, these sites need to be near the Martian equator. That rules out the southern crater with the gullies on its rim and the strange slumping stuff within. In fact, it rules out about 95 percent of the surface of Mars.

Happily, the three landers are not the whole story. The latest generation of orbiters is revolutionizing the study of Mars from space, discerning ever smaller surface features and analyzing terrain with increasingly sophisticated tools. Cameras on NASA's Mars Global Surveyor (MGS) and Mars Odyssey watch the planet day

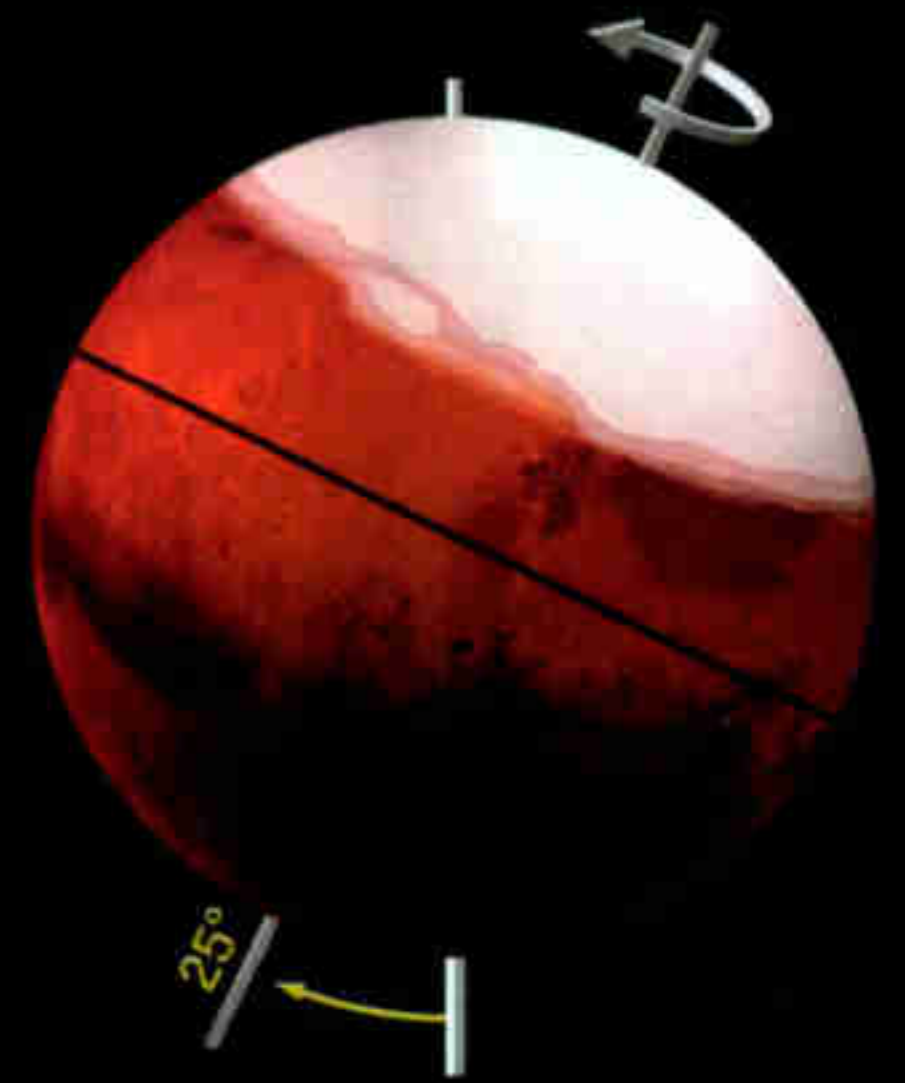
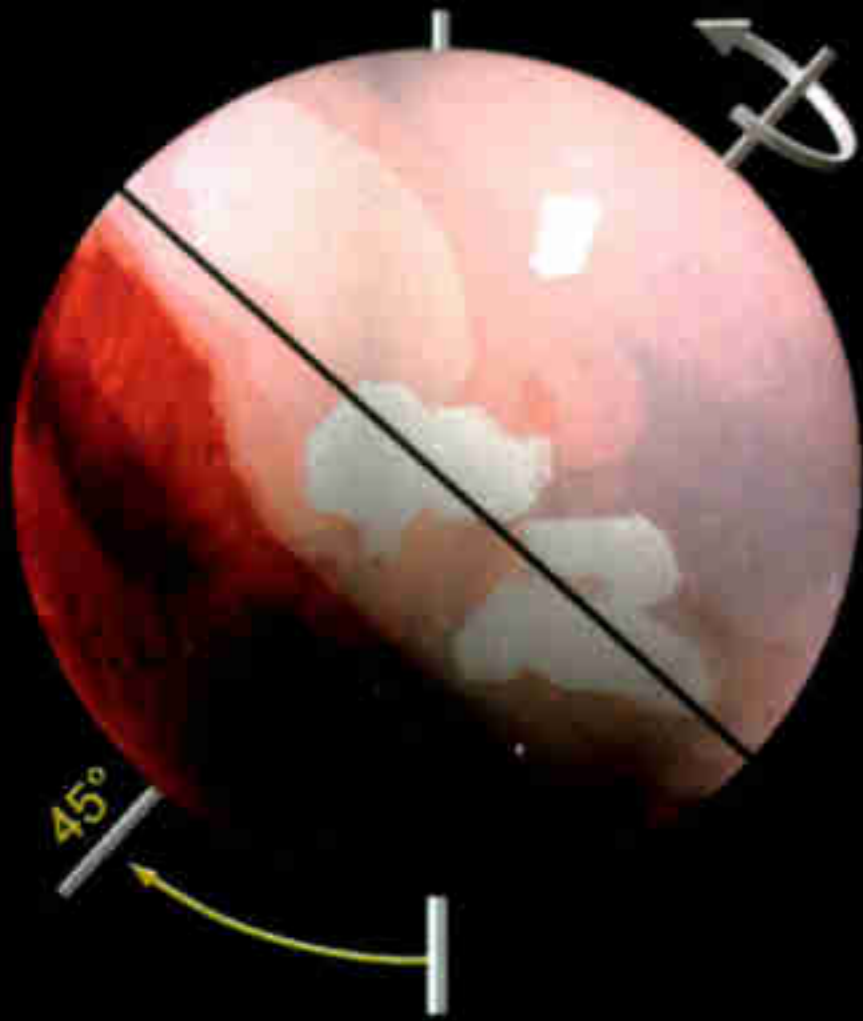


MARS'S ICE DANCE

How can there be water ice at the equator in one era but not in another? Scientists point to Mars's wildly fluctuating tilt as a key to climate change. Several factors, such as the positions of other planets, cause Mars to tilt back and forth in relation to the sun. The planet has swung between

15° and 35° some 50 times in five million years, scientists believe, and between 0° and 60° in the more distant past. When Mars is heavily tilted (two globes at left)—high obliquity—the poles get more sun exposure, causing water ice to vaporize and build up at lower, colder latitudes. At a milder tilt of 35° (third globe), the process begins to reverse, and ice leaves lower latitudes and condenses at the poles. At the current 25° (lower right), visible water ice is concentrated at the north

pole. (The diagrams show Martian winter in the northern hemisphere.) Obliquity variations as small as one degree can contribute to ice ages on Earth.



Ice-free surface Microns mm cm

SOLID WHITE AREAS INDICATE WATER ICE THAT LASTS THROUGH THE MARTIAN SUMMER, RANGING FROM CENTIMETERS TO MANY METERS DEEP. TRANSLUCENT WHITE AREAS INDICATE THIN ICE THAT MELTS IN THE SUMMER. CARBON DIOXIDE ICE, OR DRY ICE, EXISTS ON MARS BUT IS NOT DEPICTED. DATA: MARK I. RICHARDSON AND MICHAEL A. MISCHNA, CALIFORNIA INSTITUTE OF TECHNOLOGY; R. JOHN WILSON, NOAA/GEOPHYSICAL FLUID DYNAMICS LABORATORY

and night in visible and infrared light. Other sensors on Odyssey detect gamma rays and neutrons radiated from the minerals below, revealing to those versed in nuclear physics the abundance of different elements, such as hydrogen and iron.

When Mars Express reaches the planet, it will add yet more instruments to those already aloft, including a multispectral imaging spectrometer that can identify minerals using visible and infrared wavelengths, and a radar that may detect ice and liquid water below the surface. Also due to arrive in December is Japan's Nozomi orbiter, designed to study Mars's atmosphere.

As they beam a continuous stream of fresh data to Earth, the orbiters evoke a thrilling new picture of Mars—and a genuinely puzzling one: While searching for answers to old mysteries, the orbiters are bombarding us with new ones. Hugh Kieffer, a Mars veteran at the United States Geological Survey (USGS) who has been studying the planet for almost four decades, tells his younger colleagues they are in a “period of

maximum confusion.” New data—whole new types of data—are accumulating faster than researchers can make sense of them. The result is

something like an optical illusion. Contradictory images of Mars seem to flicker in and out of focus in the mind's eye.

“Although Mars is supposed to be the god of war, the planet is much more like a prima donna,” says Nathalie Cabrol, a planetary geologist at NASA's Ames Research Center. “When you think you have it right, Mars always has a surprise.”

The man whose imagination first took him to the crater rim on the edge of the butterscotch plain is Philip Christensen, a geology professor at Arizona State University in Tempe. Christensen leads the team responsible for designing

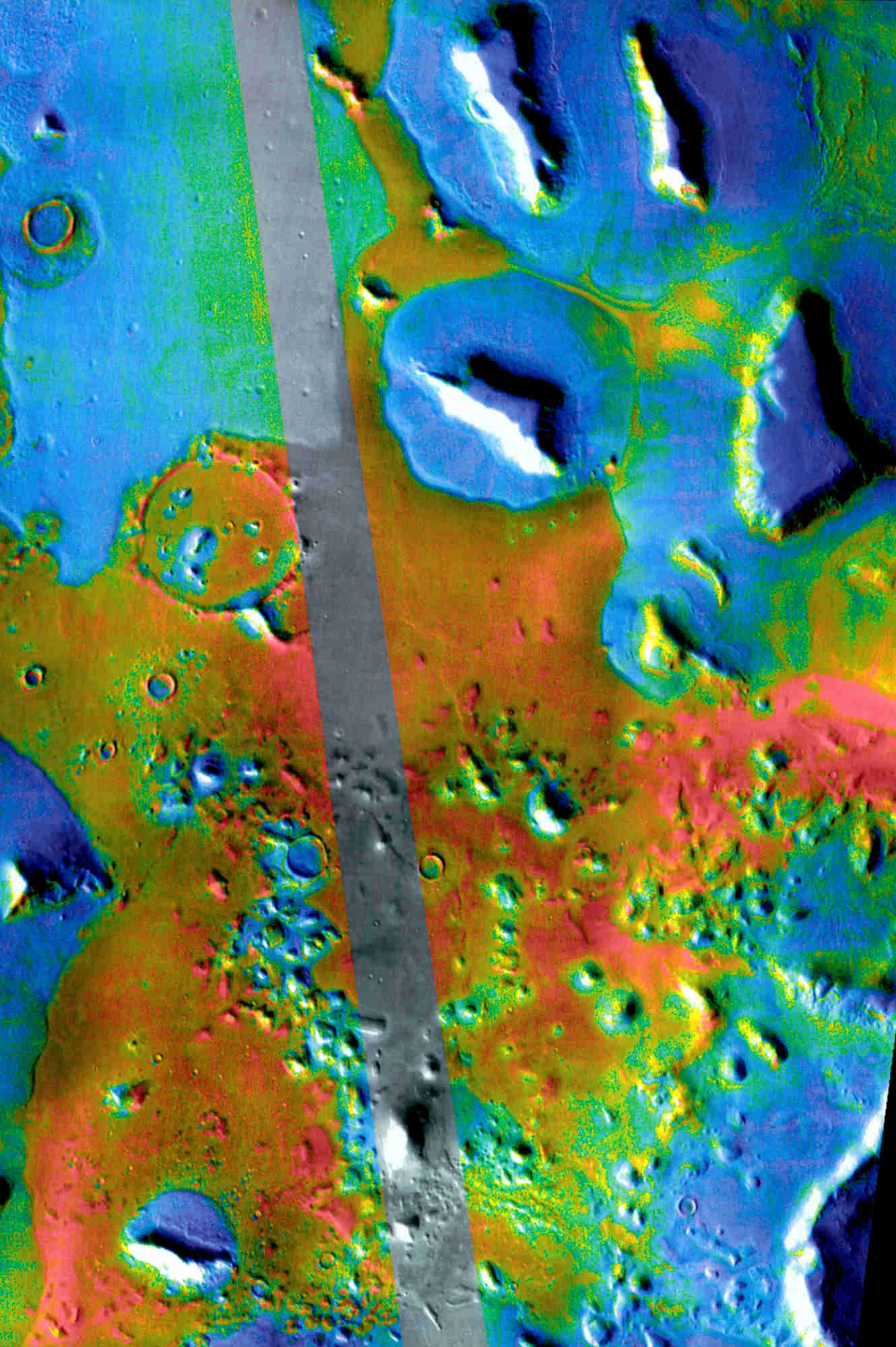
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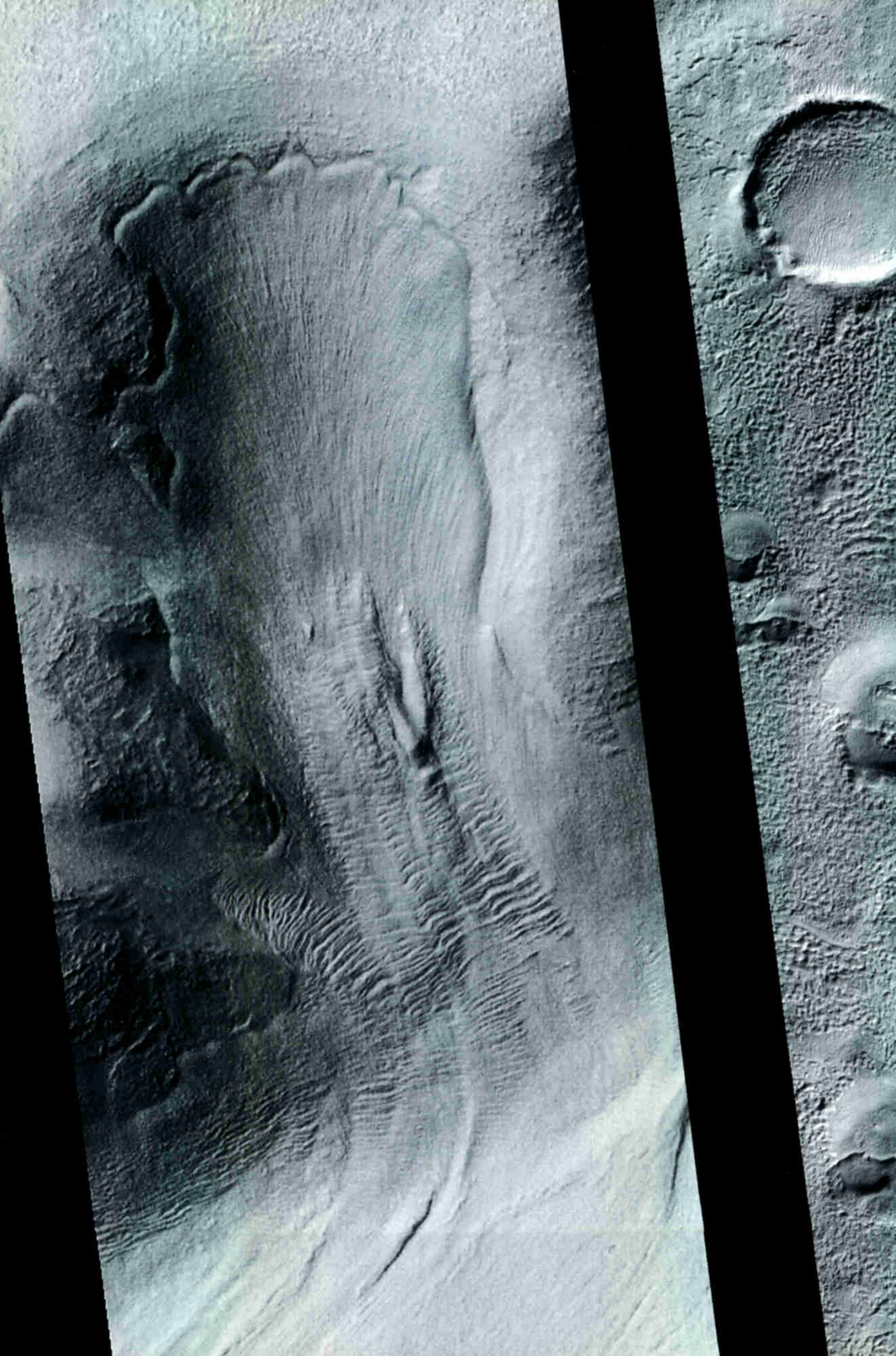


FROZEN FINDS

Do glacial flows shape the surface of Mars even now? That contention is gaining currency among Mars scientists. "These are glaciers—not soil with a little ice in them," says Phil Christensen. Faint whitish "flow lines" visible in this image beneath the black-shadowed canyon wall indicate that glaciers are moving through the valley. More evidence of flowing ice is visible in the cluster of mesas in the image at right. Colors show temperature: red for rocky ground that retains heat at night, greens and blues for sand and dust that lose heat quickly. The sharp delineations between cold material flowing off mesas and the rocky valley floor spurred the hypothesis that material had flowed off the mesas on a layer of ice. The image combines THEMIS nighttime infrared and daytime visible-light views.

NOEL GORELICK, ASU; NASA/JPL (BOTH)
APPROX 35 KM x 55 KM
APPROX 55 KM x 80 KM (RIGHT)



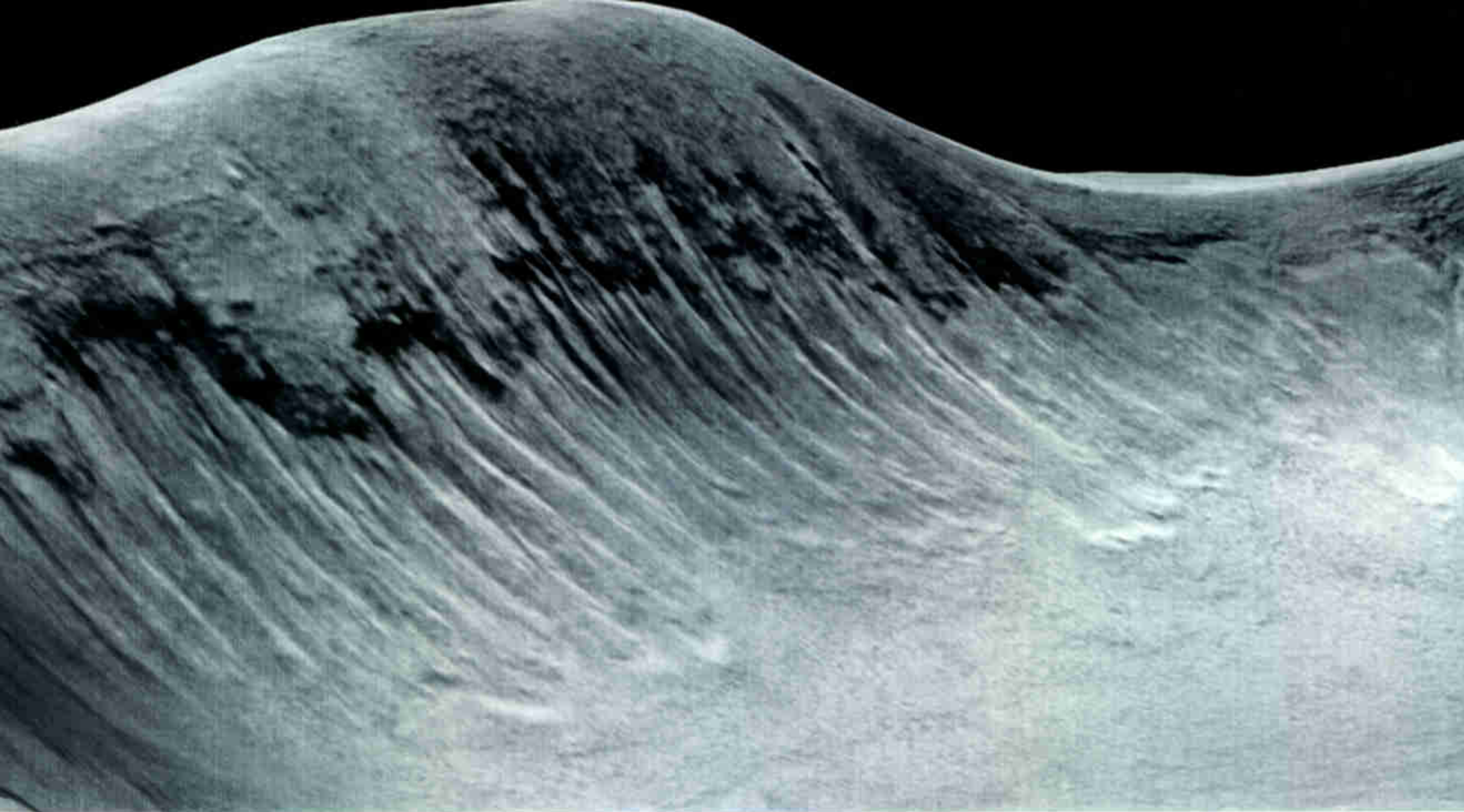




ICE STORIES

Images like these are generating debate in the Mars research community. Here high-resolution views from the Mars Orbiter Camera (MOC) aboard MGS show remnants from the last time snow and ice covered the planet's mid-latitudes. At far left, the large mitten shape could be a dust-covered icy glacier rather than a rocky glacier. Rippled ridges and flow features appear at the bottom. In the image at right, dark gullies lie beside apparent remnants of another glacier. What cut the gullies? Liquid water is the leading contender, but scientists puzzle over its source. Ice once suffused the dust that blanketed the craters and hills shown at center. A changing climate is slowly vaporizing the frozen water, according to geologist Jack Mustard of Brown University, causing the layer of dust to crumble and erode.

MALIN SPACE SCIENCE SYSTEMS (MSSS) AND NASA/JPL (ALL)
EACH IMAGE APPROX 3 KM WIDE



and building the Thermal Emission Imaging System (THEMIS), the instrument on board *Odyssey* that generates pictures of the surface in visible and infrared wavelengths. When THEMIS sent back its picture of that crater and its strange lining in the early summer of 2002, Christensen had what every scientist yearns for—a eureka moment. For the first time he thought he could see how Mars's mysterious gullies might form.

Two years earlier geologists Michael Malin and Ken Edgett had spotted what looked like recently carved gullies in images from the Mars Orbiter Camera (MOC), which flies aboard MGS. Malin, who designed MOC and set up the company that operates it, and Edgett, who actually targets the camera, saw gullies up to a couple of kilometers long and a few tens of meters wide on crater rims, canyon walls, and other inclines all over Mars's midlatitudes.

The shape and freshness of the gullies made Malin think that they had been carved by running water within the past few million years—and possibly much more recently. He soon convinced the rather more skeptical Edgett, and the two went public with their theory in June 2000. The announcement, made during a big press conference at NASA headquarters in Washington, D.C., sent an immediate shock wave through the field: It required scientists to reexamine their view of the planet.

It's not the first time an old Mars has been killed by new data. Until *Mariner 4* zipped past

in 1965, taking pictures as it went, earthbound astronomers had imagined a place at least a little like home, though much colder and with thinner air. But *Mariner 4*'s snapshots of Mars showed a heavily cratered surface far more moonlike than earthlike. Readings showed the atmosphere—composed of almost pure carbon dioxide—was even thinner than had been thought, exerting just one percent of the pressure at sea level on Earth. A new Mars was born, an inert, barren place with a rime of carbon dioxide frost. On this Mars there was no room for life.

Then in the 1970s this Mars too was killed. Orbiting spacecraft—first *Mariner 9* and then the two *Viking* missions—showed there was much more to the Martian surface than craters. *Mariner 9* saw volcanoes twice as tall as any on Earth. There were canyons as deep as the Earth's deepest ocean trenches. There were what appeared to be desiccated river systems. There were plains scoured by floods large enough to drain the Mediterranean in a month.

Pictures from these orbiters introduced another new Mars: one that was not just a dead rock but rather a fascinating fossil. In the planet's youth, scientists had theorized, the atmosphere was thick, the greenhouse effect strong, and water flowed through the valleys. But the greenhouse had been temporary; the atmosphere thinned, and the planet cooled. Except for the scraps frozen into the polar caps, its water was lost to space or stored away as subsurface ice. And this all happened billions of



SNOW BOWL

It's not much of a crater as Martian craters go—just a nameless 18-kilometer-wide hole in the southern hemisphere. Yet it's galvanizing the debate on whether water could carve gullies like those at left. Exposed water vaporizes in Mars's thin atmosphere. So how could water stay

liquid long enough to carve the gullies? Phil Christensen theorizes that as the sun warms dust on a snowpack, heat melts subsurface snow, creating water that erodes the ground. Geologist Michael Malin, co-discoverer of Martian gullies, argues instead that liquid water trapped deeper

in the ground suddenly bursts out with enough force to carve the gullies.

This THEMIS image is “draped” over data from the Mars Orbiter Laser Altimeter (MOLA). For detail and clarity, researchers exaggerated the crater's vertical dimension by 50 percent in image processing.

MICHAEL WYATT, ASU; MOLA SCIENCE TEAM; NASA/JPL. APPROX 12 KM x 3 KM

years ago. The early Mars had been dynamic; the Viking Mars was more or less inert and—as the Viking landers showed us—lifeless.

That was the Mars the gullies killed. It's not that it vanished, but it has been overlaid, and in places undercut, by findings from far more acute instruments aboard the current orbiters. The gullies Malin and Edgett saw in 2000 were too small to have been picked up by the Viking cameras. Indeed, it was the very fineness of their features that made them look much younger than anything the Vikings had seen. They appeared to be evidence that liquid water could have flowed on the surface in the recent past. And that led to confusion by the bucketful.

Water will stay liquid only if it's warm enough and at high enough pressure. Drop the temperature, and it will freeze; drop the pressure, and it will vaporize. Physics seems to say that Martian

midlatitudes are far too cold for liquid water to persist for any length of time at the surface. But the gullies seem to say differently. As a result some researchers suggested the gullies weren't in fact carved by water. Others invoked ice buried near the surface that had somehow melted. Malin and Edgett imagined the gully-carving fluid might come from very salty (and thus hard-to-freeze) aquifers just below the surface.

Like many of his baffled colleagues, Phil Christensen didn't much like any of the explanations. That said, he also hadn't given a great deal of thought to them, as he'd been focused instead on using infrared cameras to detect various sorts of rocks and minerals from a distance. But while watching the THEMIS pictures come in from Odyssey, he got interested in another phenomenon revealed by Malin's MOC: a strange “pasted-on layer” draped over some north- and south-facing slopes in the mid and high latitudes.



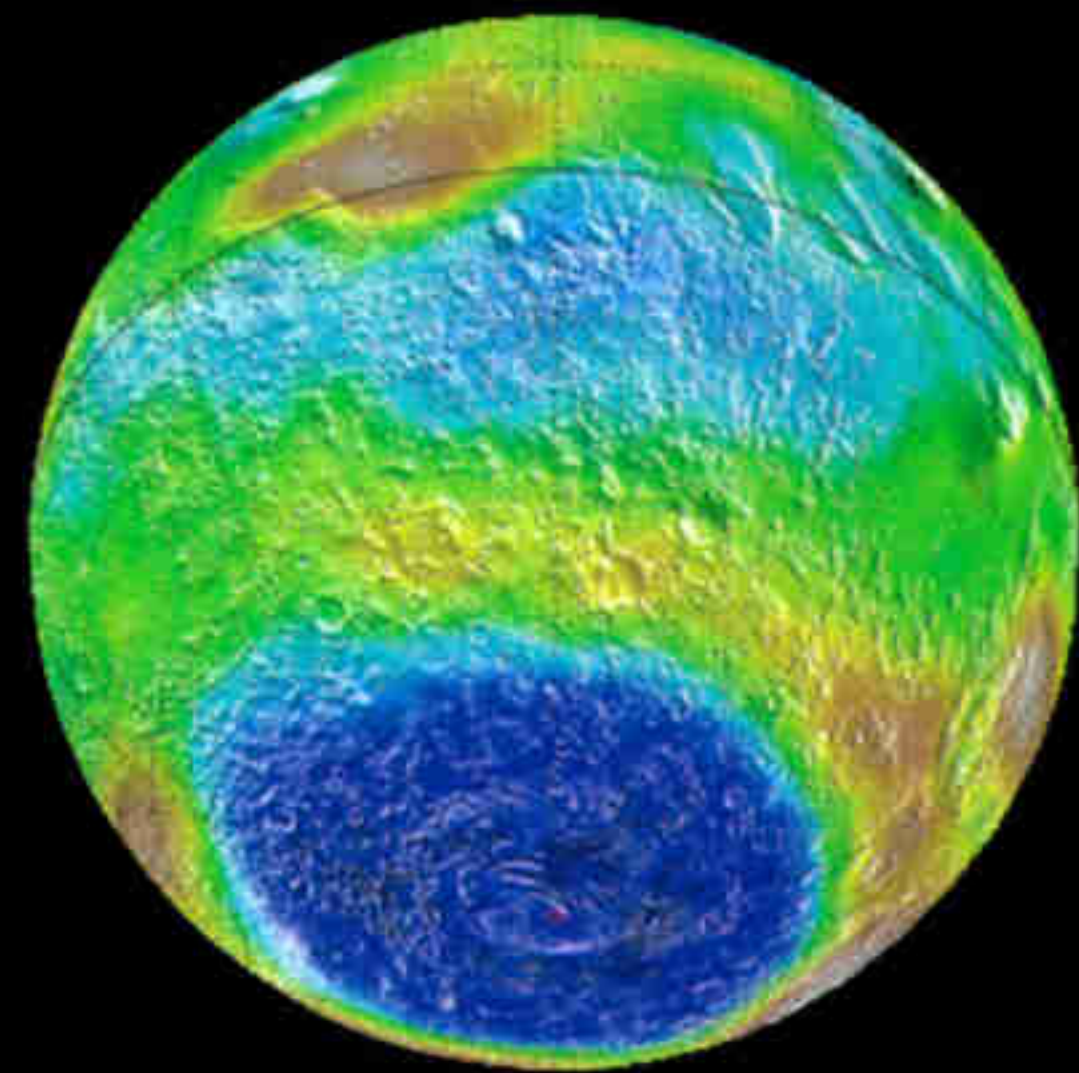
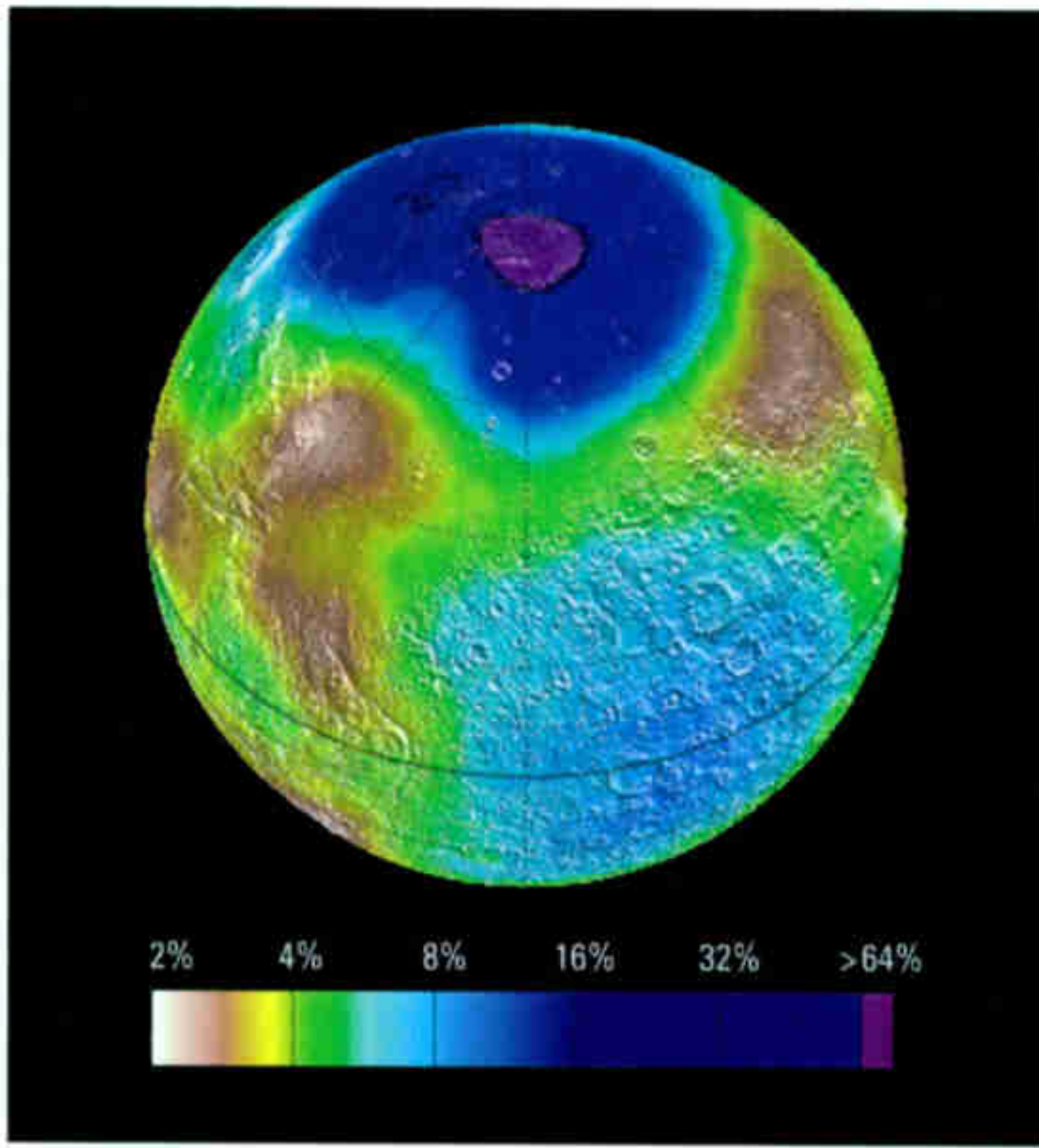
SLOPE STREAKS

Dust avalanches typically a few hundred to a thousand meters long tumble toward the center of an impact crater. "They appear to be the most dynamic features on the surface of Mars, increasing at the rapid rate of 7 percent per Martian year [687 Earth days]," says Caltech planetary scientist Oded Aharonson. He and colleagues have studied thousands of areas that feature slope streaks. What sets them off? Some say a gust of wind, but Aharonson thinks trace amounts of water can play a role. Slope streaks are found only in areas where surface temperatures rise just above the freezing point of water; the increase of pressure when water vaporizes might trigger the slides.

WATER AT THE EQUATOR?

The neutron spectrometer on Mars Odyssey looked a meter into the ground all across the planet to determine the amount of hydrogen present, which scientists infer to mean water molecules. The white and brown areas are almost completely devoid of hydrogen, approaching the dryness of the moon's surface. As the color changes to yellow, green, and then blue, the surface becomes increasingly rich with hydrogen. The key below shows hydrogen percentage by mass. It was no surprise to see proof of plenty of water around the north pole (left globe), and researchers had theorized that

frozen water was locked beneath the CO₂ ice around the south pole (right globe). But the seeming abundance of water ice extending to the midlatitudes was news to scientists. And what amazed them was the amount of water-equivalent hydrogen at low latitudes and even the equator. The vital question: Is this frozen water or H₂O chemically bound to a mineral?



Going through the latest THEMIS feedback one day, Christensen remembers, “There was this one ‘ah-ha’ image: I saw this pasted-on stuff with gullies in it. And that was it.” From a distance of 335 million kilometers or so, THEMIS had lit up a lightbulb over its creator’s head. Looking at the picture, he suddenly saw the pasted-on stuff as very dirty snow—not from its color but from the way it was draped on the landscape. When sunlight warmed the dust within it, the snow would melt from the inside out, and the meltwater, kept liquid by the insulation of the snow above, would carve the gullies.

In a little over six months this interpretation made it to the cover of the prestigious scientific journal *Nature*. One of the researchers who reviewed the paper was Mike Carr, a geologist and Hugh Kieffer’s colleague at USGS. Carr directed the team that ran the Viking orbiter cameras and is now a member of the MOC crew. He wrote the book on evidence for water on Mars (literally, it’s called *Water on Mars*) and was one of the first to report about

the pasted-on layer when it showed up in the MOC images. When he read Christensen’s hypothesis about the gullies, all he had to say to *Nature*’s editors was that he was embarrassed not to have thought of it himself.

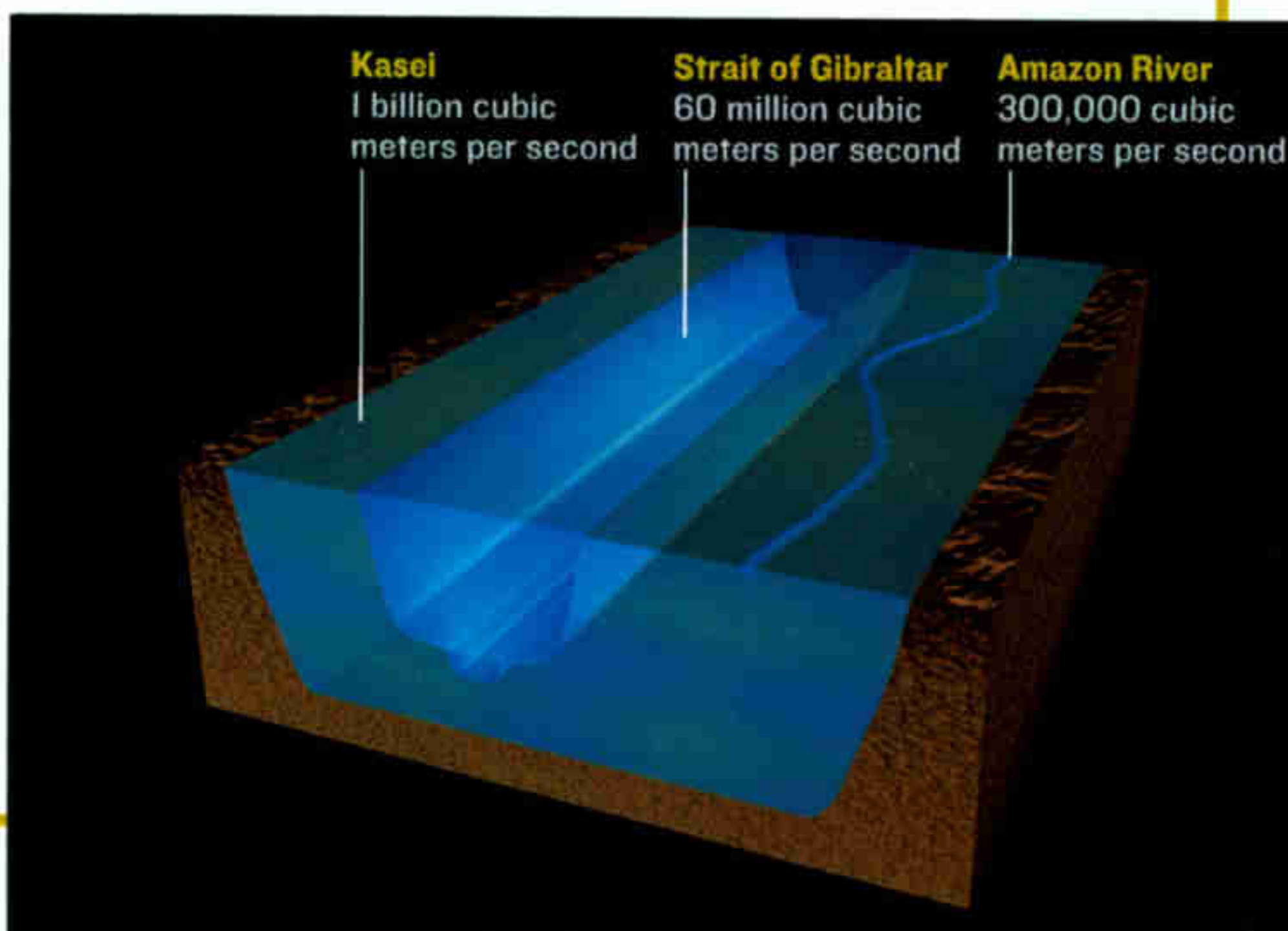
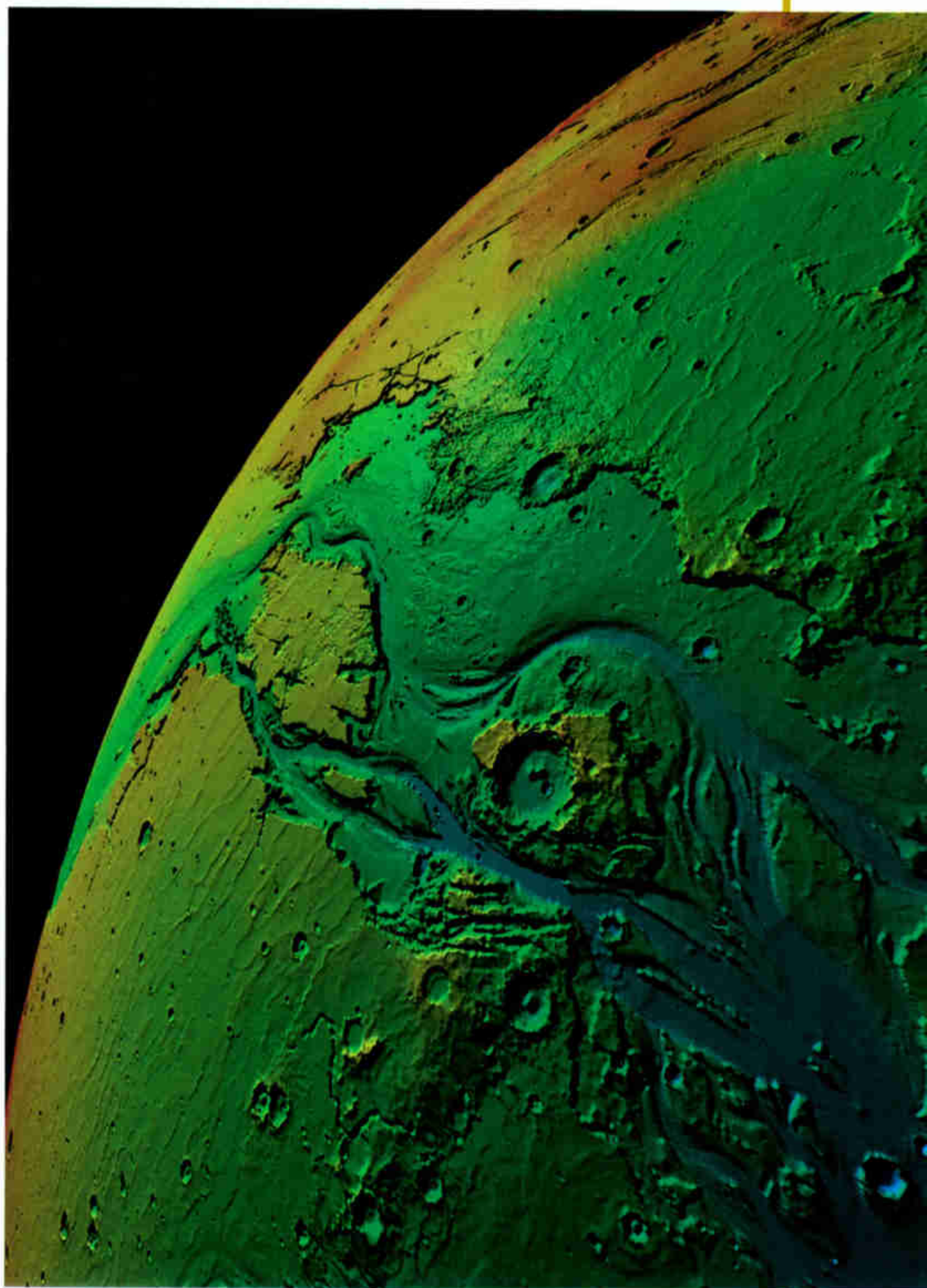
But how could there be dirty snowpacks over a large fraction of the planet’s surface? Like its liquid form, water ice is stable only within a specific range of temperature and pressure. Drop the pressure on a piece of ice far enough, and it will turn straight into water vapor, a process called sublimation. This is exactly what would happen under today’s conditions if you were to put fresh snow at the latitudes where most of the Martian gullies are found. So how could any snow accumulate there? The answer, Christensen and others have suggested, lies in changes in Mars’s obliquity—the angle between the planet’s axis of rotation and the plane of its orbit.



ANCIENT FLOODS

The sinuous channel of Ma'adim Vallis (left), one of Mars's major canyons, opens into Gusev crater, a 160-kilometer-wide basin (partially visible at the top of this THEMIS infrared image) in the cratered uplands of the southern hemisphere. A large lake in the southern highlands of Mars is thought to have overflowed about 3.5 billion years ago, gouging out the canyon as the torrent headed north and then spilled into the crater, forming a new lake. One of two NASA planetary rovers (see page 27) is scheduled to land in Gusev this month to search for sedimentary rocks.

Geologic violence on Mars also carved the huge channel of the northern Kasei Valles (right, in a color-coded MOLA image). Despite the feature's great size—some 500 kilometers wide and nearly 3,000 kilometers long—some scientists think the catastrophic releases of groundwater that carved the valley may have lasted only weeks or months. Others believe that the water was confined underground by ice. When the ice ruptured, possibly due to volcanic activity, water burst forth violently. The water flow rate through Kasei could have been a billion cubic meters per second, dwarfing the capacity of channels on Earth such as the Amazon River and Strait of Gibraltar (art, right). Where all that water went is an important question to scientists piecing together the planet's geologic history. Perhaps some water seeped into the ground and froze, wound up in polar ice, or was lost from the atmosphere, but scientists can't account for all of it.



On Mars, as on Earth, this angle varies over time, responding to the gravitational pull of the other planets, particularly Jupiter. The poles nod up and down, and when they're down they point more directly at the sun, which makes high-latitude summers hotter. The Earth's nodding, though relatively modest, influences the rhythm of our ice ages. Mars nods much more vigorously—think involuntary spasms rather than a measured sign of assent—and the climatic effects could be dramatic. When the poles dip by 35° or so, the residual polar ice caps will no longer be stable in summer. At the same time the lower latitudes will get cooler, and the water vapor that sublimates from the polar caps will fall there as snow. When the poles shift back, the lower latitudes get warmer, and the snow becomes unstable. That's when, according to Christensen, it melts from within to form the gullies.

Mike Carr and Bruce Jakosky of the University of Colorado first suggested, almost 20 years ago, that the planet's nodding could have moved ice from the poles. The reason the idea is now coming to the fore—not just, or first, in Christensen's explanation of the gullies—is that MOC and other instruments orbiting Mars are seeing features that make the concept seem more than just a possibility. The evidence for ice looks real, and it looks recent.

Jack Mustard of Brown University has mapped what he thinks are the remains of a layer of mixed dust and ice over much of the midlatitudes that is related to Christensen's pasted-on material. Computer models of the planet's atmosphere suggest that more than once over the past few million years, tilting of Mars's axis could have moved enough water from the poles to make a layer of snow as much as ten meters thick over parts of the planet. Mustard's colleague Jim Head, Nathalie Cabrol at Ames, and Jeff Kargel at USGS, among others, all report seeing the remains of glaciers—or things that look like glaciers—in various places and at a wide range of scales, from features that dominate the flanks of giant volcanoes to the strange flow-like folds beneath some gullies.

No one person agrees with all of this, and some don't like any of it. Malin and Edgett, discoverers of the gullies, are deeply skeptical of Christensen's snow model. But that doesn't mean they think Mars is the static desert of the Viking days. In fact they believe it could be changing

on an even faster timescale than that defined by its nodding poles. Their camera, MOC, has revealed “Swiss cheese” holes in the solid carbon dioxide of the southern polar ice cap, holes that grow from year to year. It's possible, they say, that over a century or so, those holes could add enough additional carbon dioxide to the atmosphere to ratchet up the greenhouse effect and trigger subtle changes elsewhere.

The most dramatic evidence for change going on right now, beneath our orbiting eyes, comes from what could be seen as the least dramatic features on Mars: slope streaks. These are just what their name implies—streaks that run down slopes like two-dimensional stains. A commonly accepted explanation is that they are very thin avalanches of dust slipping away to reveal a darker surface beneath.

Norbert Schörghofer and Oded Aharonson at Caltech have been studying the images of slope streaks sent back by MOC. To their surprise, they found that the number is growing from year to year at what Aharonson calls “an incredible rate.” For every hundred existing slope streaks there are seven more every Martian year, making them among the fastest changing surface features on Mars. But the pace of their creation is only part of the story. What seems really remarkable is that their occurrence looks as though it may be related to the presence of traces of water.

Given how they're thought to form, you'd expect slope streaks to turn up in dusty places and on relatively steep terrain. Examining MOC images and altitude measurements from MGS, Schörghofer, Aharonson, and their co-workers confirmed that the streaky regions were indeed dusty and rich in ups and downs. But something didn't quite fit. Mars offers plenty of slope-rich dusty areas completely free of streaks. What makes the streaky regions different?

On a hunch, the scientists looked at readings from the Thermal Emission Spectrometer on MGS, which records the surface temperature at any given place on Mars. Bingo! The slope streaks appeared in regions where, for some of the year, the temperature at the warmest time of day crept above the freezing point of water. So in places where water might appear, just fleetingly, something seems to destabilize the dust and let it slip. In places where water is not



NOW YOU SEE IT, NOW YOU DON'T

To the eye, tortured patterns and baroque designs (above, at top) twist across a field of ice near Mars's south pole. But in a THEMIS nighttime infrared view of the exact same place (above, at bottom) the landscape appears as a monotonous gray expanse. Why? The area is varnished with

about a meter of CO₂ ice, or dry ice. It looks blank because infrared imaging sees only the ice's uniformly cold temperature—here about minus 130°C. The ice's clarity may be due to a self-cleaning effect. When sunlight hits dust particles frozen inside, the particles heat up. The ice around them

vaporizes and the particles fall down through the ice to the planet's surface. The visible black spots could be vents allowing the release of CO₂ vaporized by sunlight. A person standing near the vents might hear the roar of CO₂ gas escaping into Mars's thin atmosphere.

PHILIP CHRISTENSEN, ASU; NASA/JPL (BOTH), 30 KM x 18 KM

expected to occur, no such thing happens. This doesn't necessarily prove that ice sublimating, or melting and refreezing, triggers the dust avalanches. But water—maybe only a trace—seems a distinct possibility.

From Percival Lowell at the turn of the 20th century to theories based on Viking data in the 1980s and 1990s, the story of Mars has almost always been told as a long planetary diminuendo—a slow sinking from the vibrant to the moribund. Lowell thought Mars was covered with canals because it was drying out and that the canals were an ancient civilization's last-ditch—last megaditch—attempt to stave off the planet's decline into waterless and lifeless senility. From then until now people have maintained that planetary activity—volcanism and crust movement—is driven by internal heat, that a smaller world like Mars will necessarily cool down much quicker

than a bigger planet like our own, and that we have therefore missed its glory days.

True as far as it goes: Mars is not the hot-hearted volcano-building place it once was. But if the planet is no longer active in the way Earth is, it's still exquisitely reactive, responding to little orbital pulls and shoves with planet-girdling sheets of dirty water-ice or snow that bring striking changes to its surface. Its capacity for change is no longer buried in the distant past. Instead this change is almost contemporary, sometimes happening on the same 10,000- to 100,000-year timescales as the Earth's ice ages, if not quicker. Mars is no longer a world of endless decline, but one of rhythmic regeneration. That regeneration may include occasional splashes of liquid water, making Mars a more plausible abode of life than it has seemed since the Viking missions.

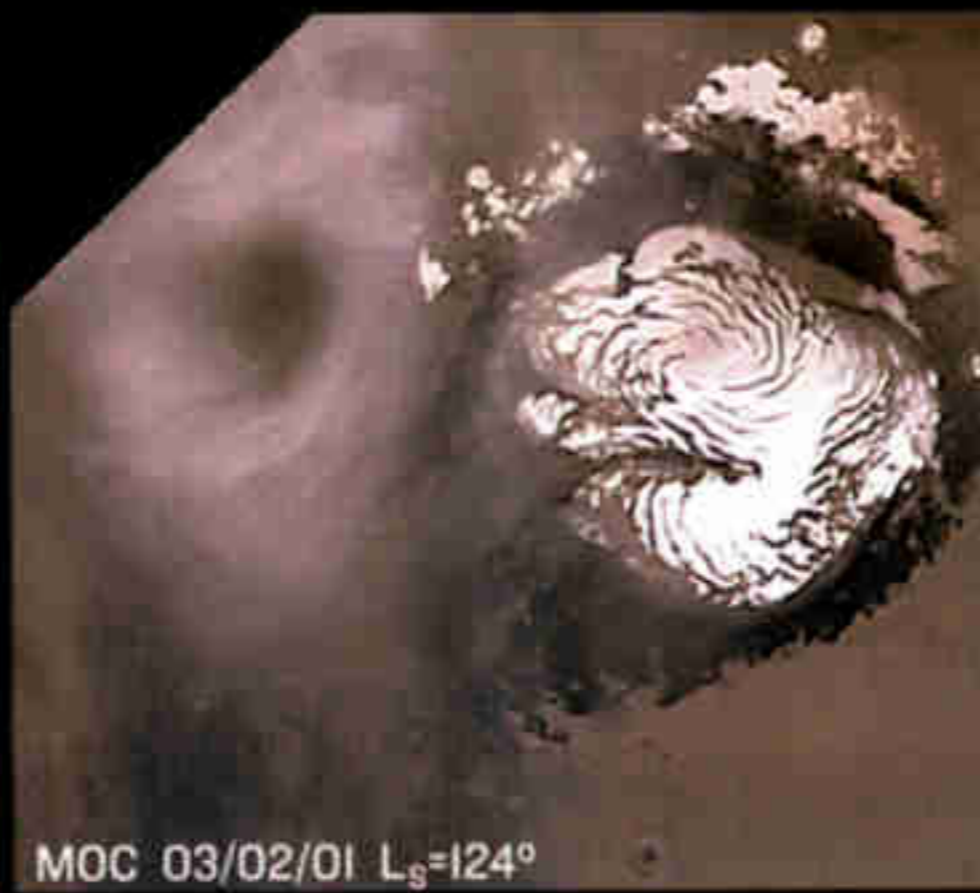
While the orbiters continue to show us more of the planet's cold, capricious present, the current landers are slated to (Continued on page 28)



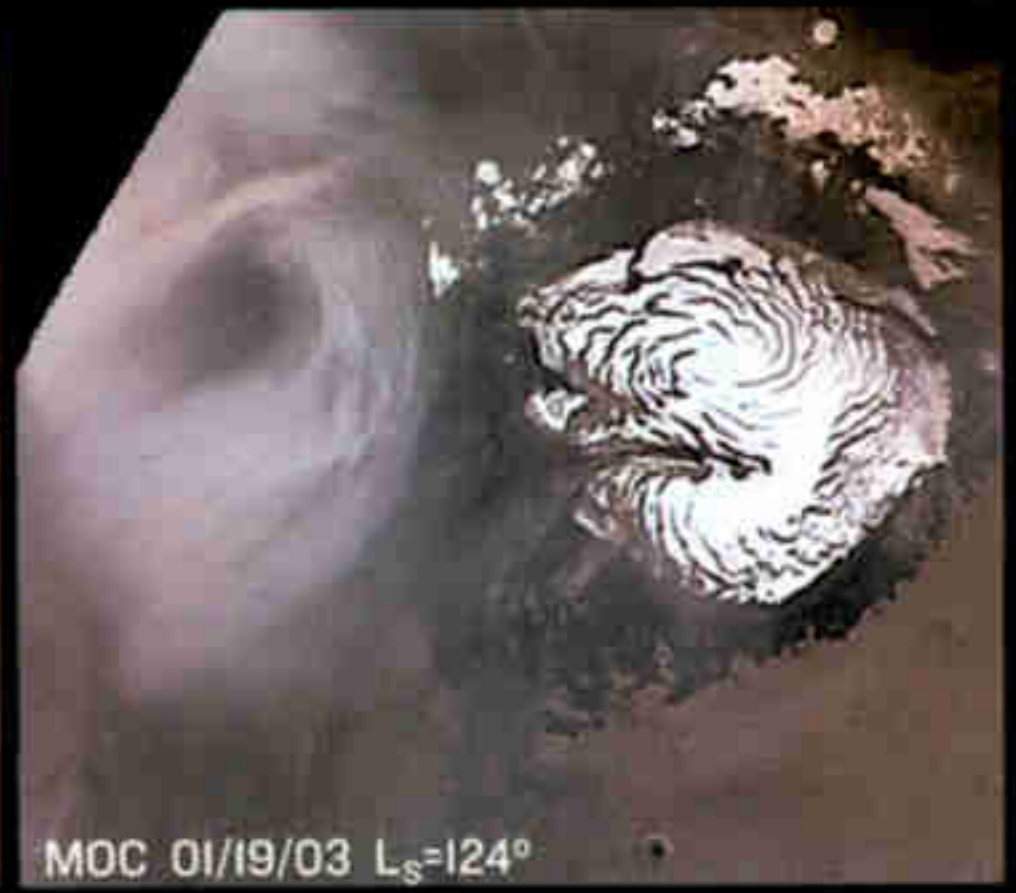
Triple Whammy Three Mars years in a row, a nearly identical cloud formation (below) approached the north pole each day for three weeks in northern midsummer, showing the repetitiveness of the planet's weather. Elsewhere, bluish water-ice clouds and dust plumes (above) rise over Arsia Mons, one of Mars's giant volcanoes, where a spiral dust storm circles within the summit caldera, at center.



HST-WFPC2 04/27/99 $L_s=130^\circ$



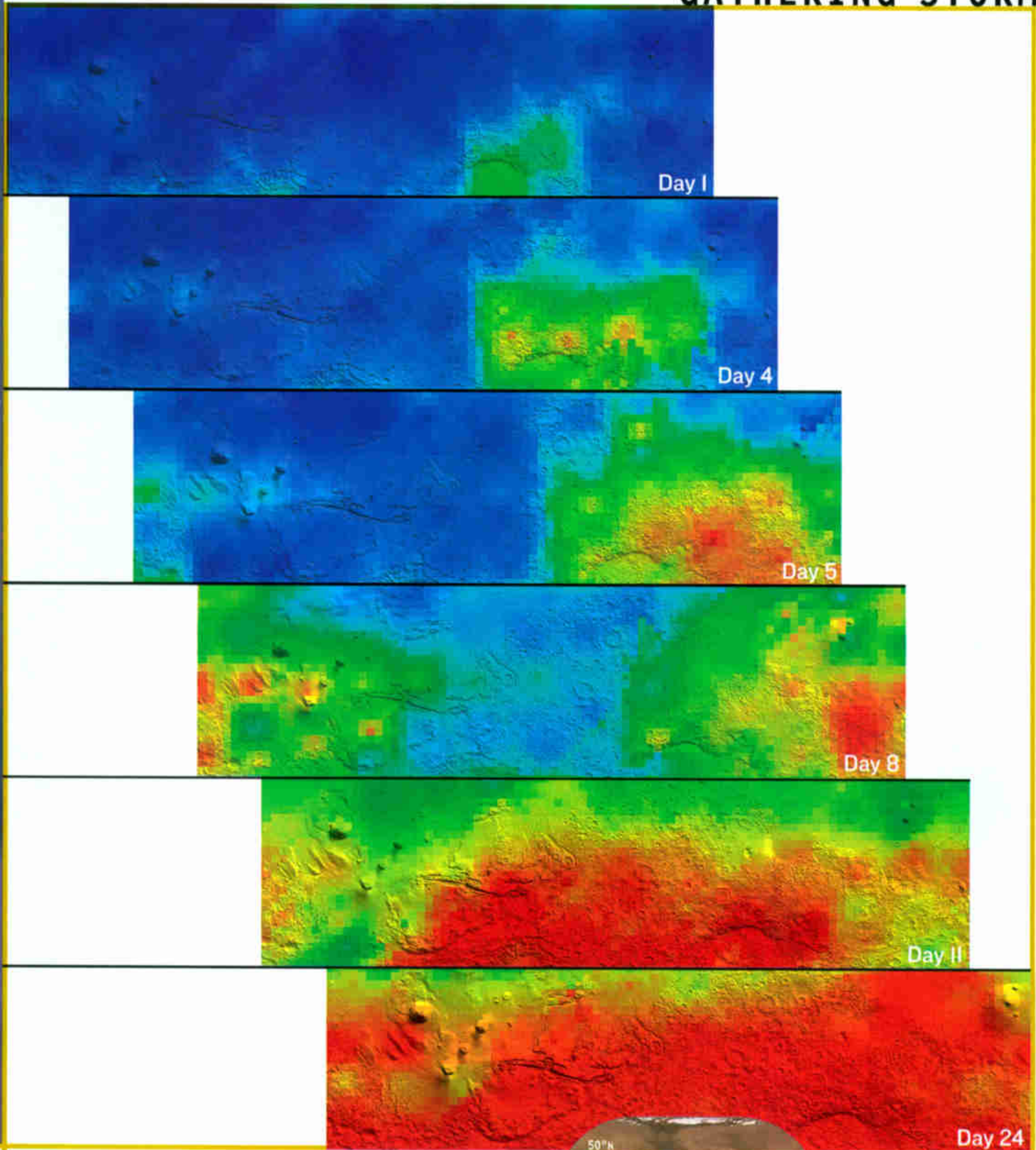
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MOC 01/19/03 $L_s=124^\circ$

MSSS AND NASA/JPL (TOP, ABOVE CENTER, AND ABOVE RIGHT). IMAGE FROM HUBBLE SPACE TELESCOPE (ABOVE LEFT): JIM BELL, CORNELL UNIVERSITY; STEVE LEE, UNIVERSITY OF COLORADO; MIKE WOLFF, SPACE SCIENCE INSTITUTE; NASA/SPACE TELESCOPE SCIENCE INSTITUTE
 TOP: APPROX 1,350 KM x 1,215 KM; EACH ABOVE: 2,700 KM x 2,450 KM

GATHERING STORM

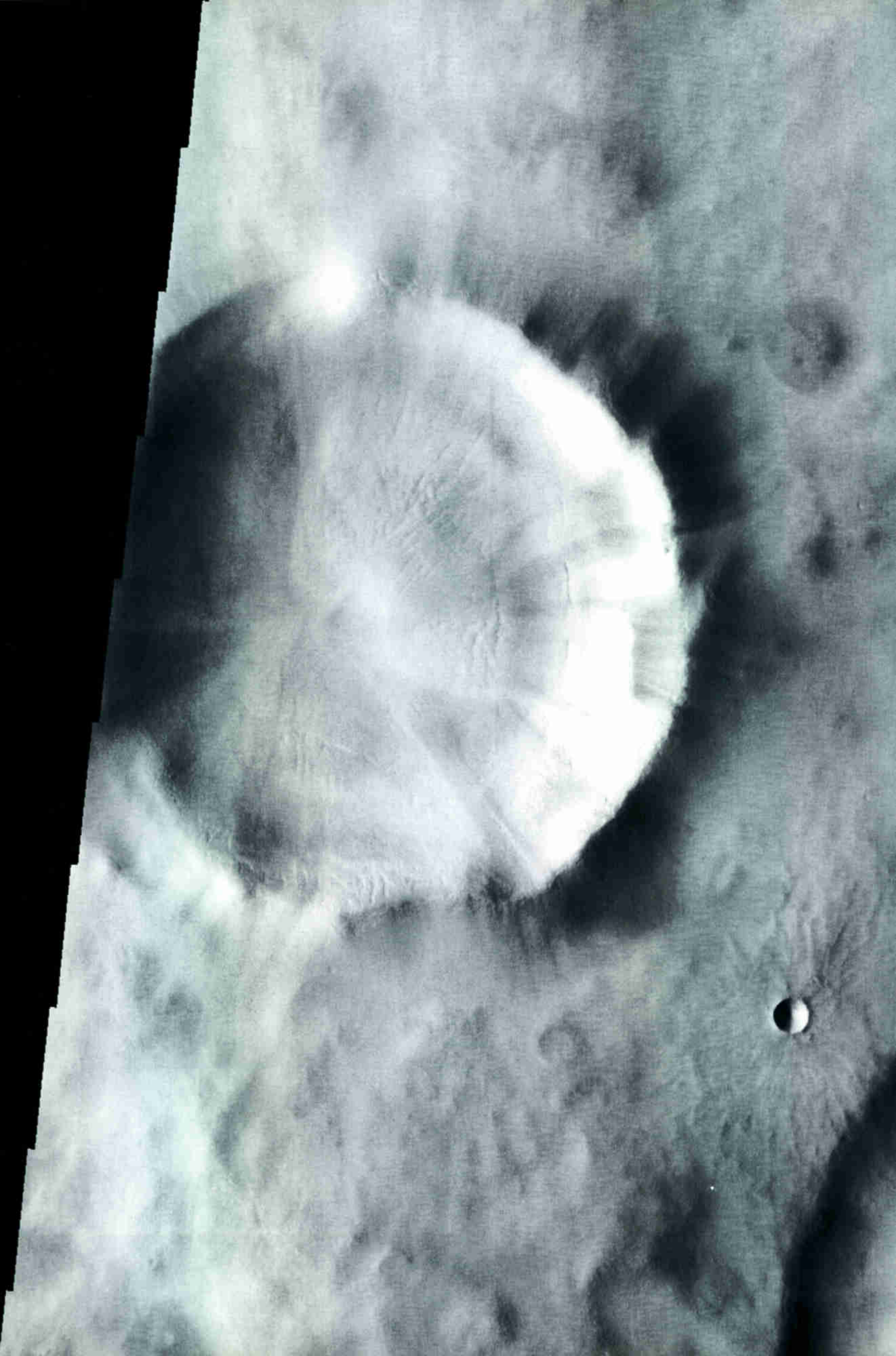


Just as Mars's extinct river channels outstrip their counterparts on Earth, the weather events on the red planet have no earthly equivalent. During 24 days in April 2001, a storm grew to envelop most of the planet in a choking mantle of dust. Recorded by the Thermal Emission Spectrometer on MGS and shown in false color, the dust appears yellow, orange, or at its thickest,

red. The images show how the storm grew to encompass nearly a quarter of the planet by day four. Particles kicked up by the storm were carried elsewhere, causing atmospheric temperatures to rise. That spawned new storms, which on day 11 were exploding everywhere between 50° north and south of the equator. Storms



like this can obscure the planet's surface for months. When Mariner 9 arrived in November 1971, the biggest dust storm yet observed was in progress, shrouding all but the summits of the four highest mountains on Mars, including 26-kilometer-high volcano Olympus Mons, the tallest peak in the solar system.

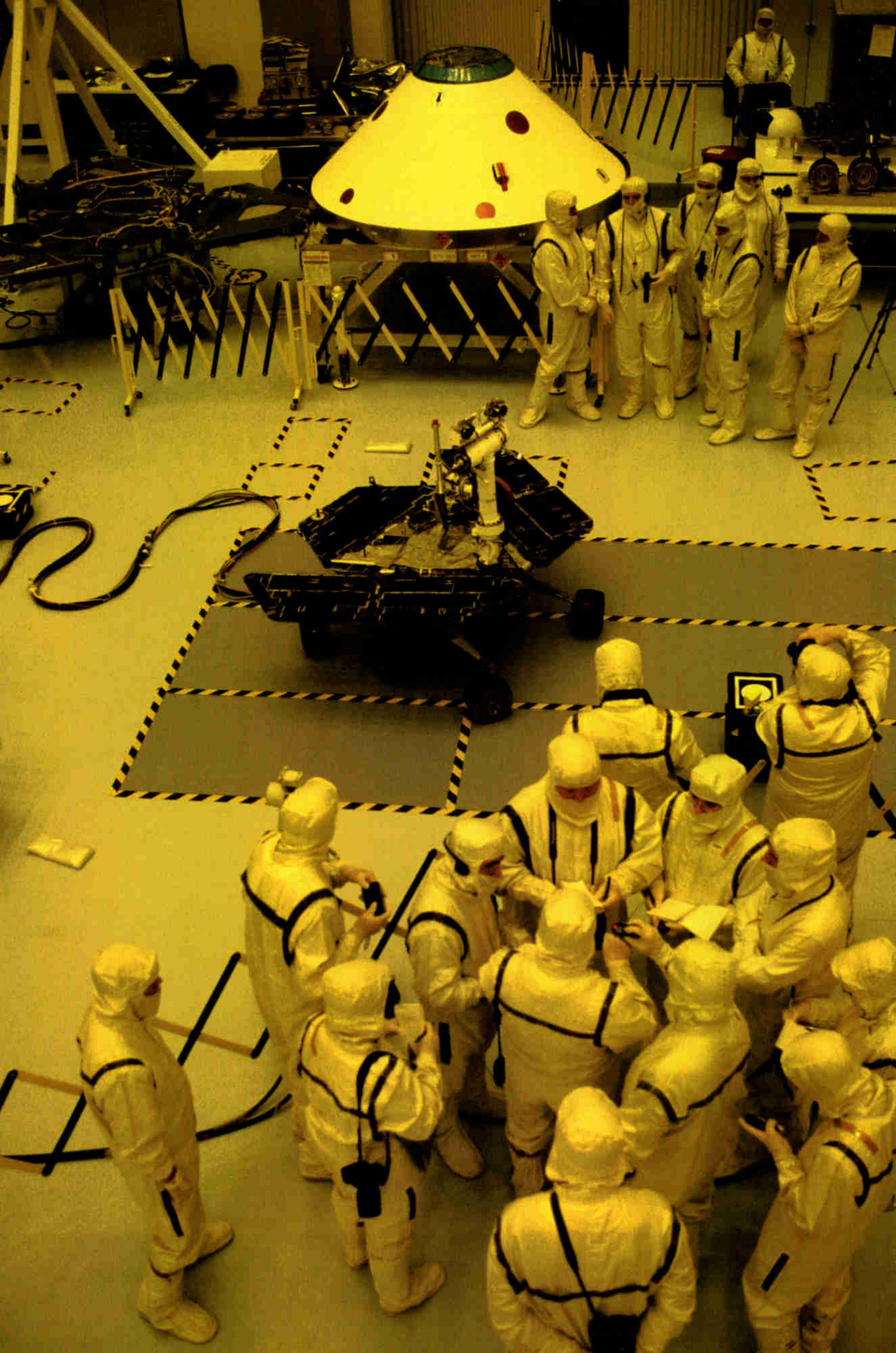




DAY AND NIGHT

A puzzling pattern peeks out of this crater. It can barely be seen in a THEMIS visible-spectrum view (left). But a nighttime infrared image (above) makes clear why it has been called a pinwheel crater. Contrasting light and dark sections indicate higher and lower temperatures, respectively —perhaps alternating wedges of rock and sand moving down-slope. What caused the pattern, however, remains a mystery.

ASU AND NASA/JPL
18 KM x 27 KM (LEFT); APPROX 16 KM x 22 KM (ABOVE)



DESTINATION MARS

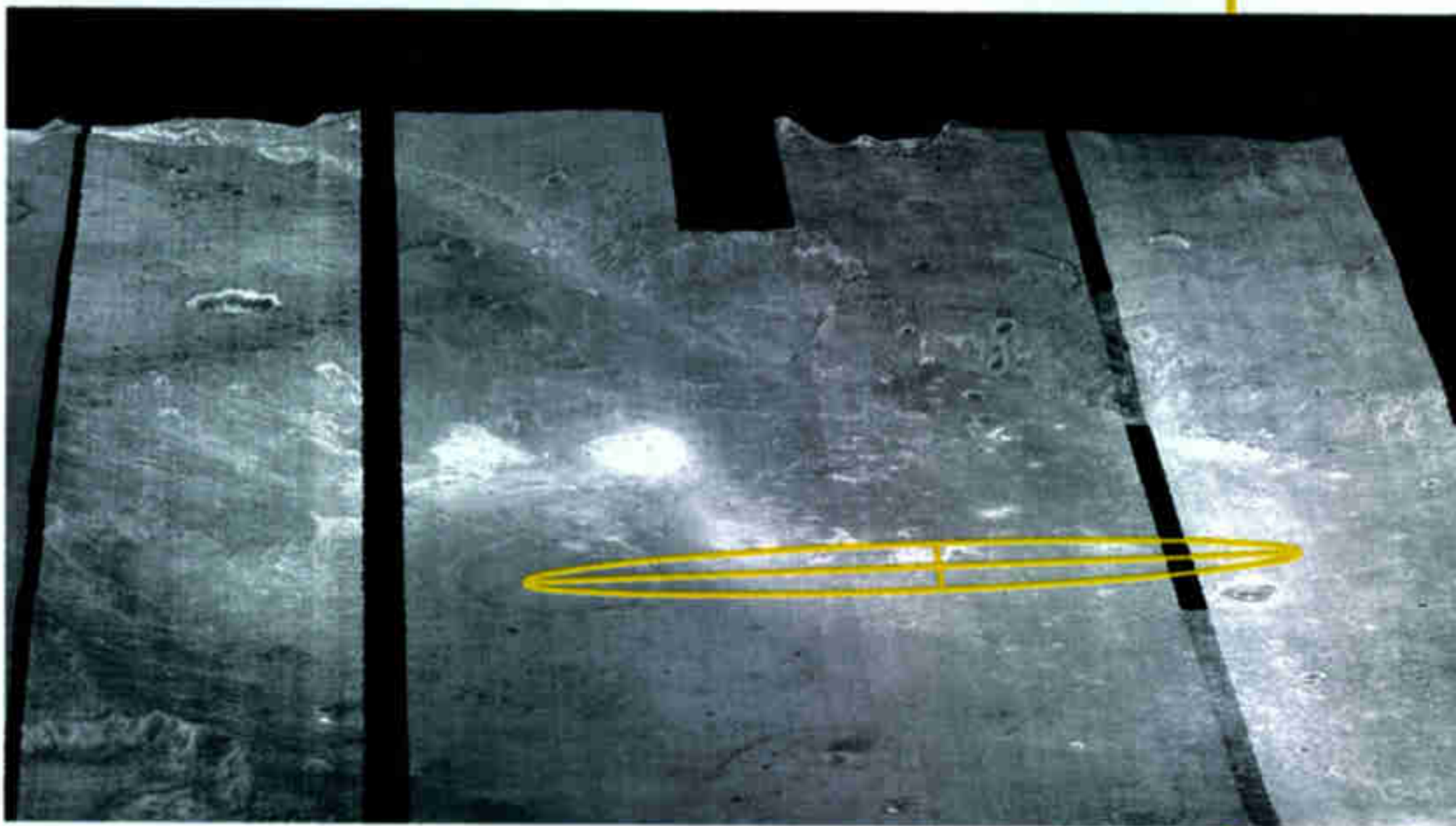
U.S. Hunts for Signs of Water

Forget invasions by little green men from Mars—these yellow Earthlings are readying robots to send the other way. In a clean room at Kennedy Space Center in Florida, journalists, engineers, and technicians examine one of two identical Mars Exploration Rovers (MERs). The solar- and battery-powered rovers, Spirit and Opportunity, can travel up to 40 meters a day on missions designed, in part, to determine if liquid water persisted long enough to make Mars hospitable

to life. Launched in June and July, they're scheduled to land this month.

Encased in protective air bags, the 174-kilogram (384-pound)

rovers will bounce up to a kilometer before coming to rest. The 80-kilometer-long landing sites (indicated in each image by an ellipse) were chosen for safety as well as for science. Spirit will land in Gusev crater (lower right), possibly a former lake basin. Opportunity's target is Terra Meridiani (top), rich in gray crystalline hematite, a mineral formed mainly in the presence of water.



Europe Looks for Alien Life

The Beagle 2 lander combines scientific daring and understatement in a tiny 68-kilogram package that in its folded state resembles a giant pocket watch. Launched on June 2, it's slated for a December 25,

2003, landing on Isidis Planitia near Mars's equator. The stationary craft unfolds and deploys a robot arm.

Unlike the U.S. rovers, Beagle 2 is tackling the quest for extraterrestrial life. Instruments on board will analyze



soil samples for chemical signatures of biological processes and can sniff for methane gas, an indicator of current life.

If it succeeds, the craft, named for the ship that carried Darwin as he pondered evolution, could forever alter our view of life in the universe.

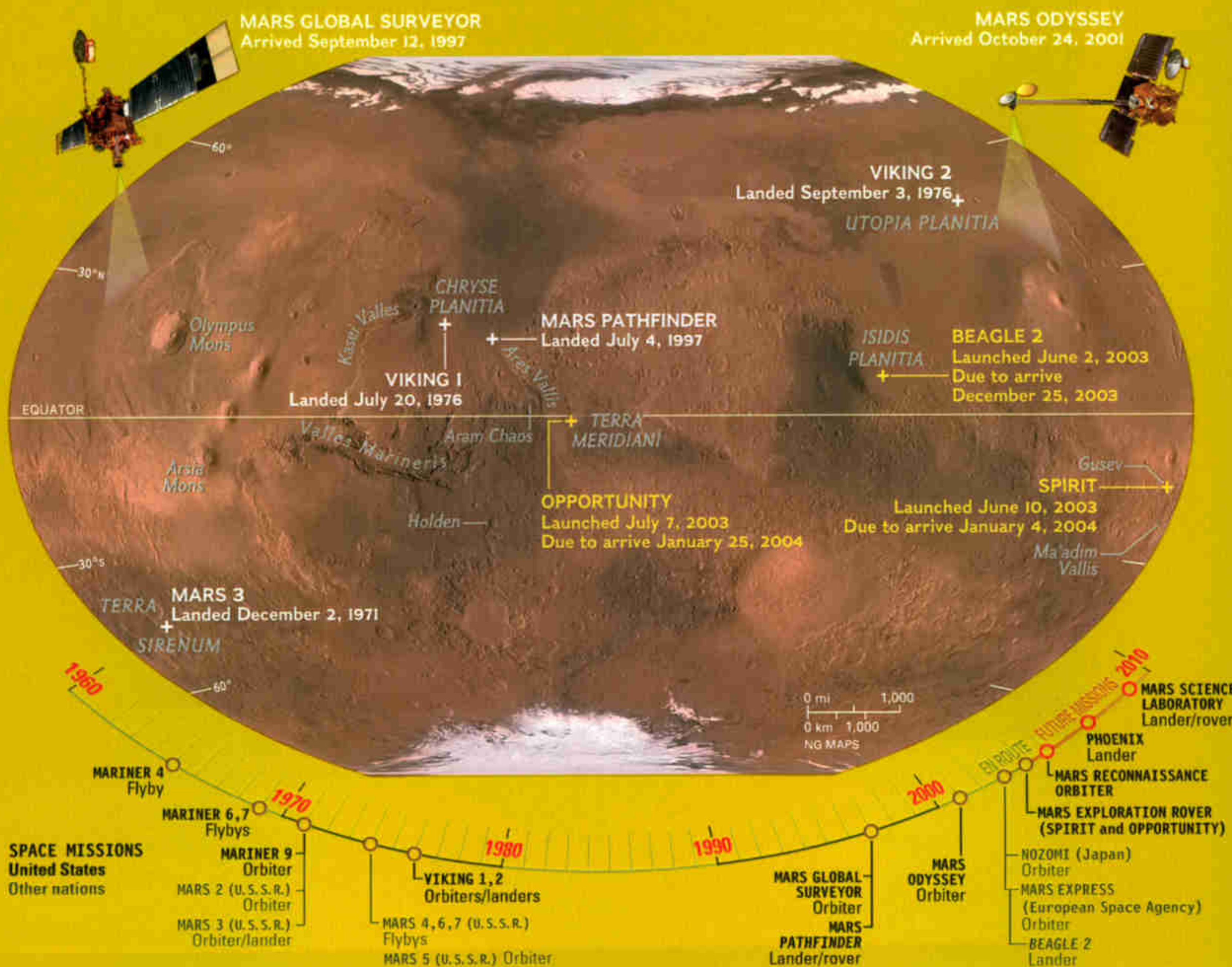
(Continued from page 21) go to places that tell the story of an older Mars. Beagle 2 is targeted at Isidis Planitia, a large equatorial basin. Spirit and Opportunity are headed for regions where water may have shaped the geology near the surface billions of years ago. According to infrared readings, Opportunity's landing site in Terra Meridiani shows traces of a form of the mineral hematite that, on Earth, is created typically only in the presence of water. Studies by Cabrol and others (including her husband, Edmond Grin) argue that Gusev crater, the landing site for Spirit, was once a basin flooded with water from Ma'adim Vallis, a huge channel that empties into it. The bottom of the basin—the rover's intended landing site—may have been a lake bed more than once as long-lost waters came and went.

It may seem a shame that the rovers aren't going to look at the gullies, or slope streaks, or at sites near possible glaciers, or at the dozens of fascinating places that have cropped up in the past few years. However, it's fortunate that Spirit and Opportunity can get someplace so interesting. The landers don't just need flat plains near the equator, they need low levels of dust, a scarcity of boulders, and gentle winds.

The fact that two sites as intriguing as Gusev and Terra Meridiani seemed safe enough to try for came as a relief to mission scientists. Terra Meridiani, indeed, is almost too good to be true: It's one of the few places on the planet where evidence for any mineral associated with water has been found; it's just about the flattest, smoothest, safest landing site anyone has ever seen; and it's pretty much slap on the equator to boot.

MARS EXPLORATION

PAST, PRESENT, AND FUTURE



MARS IMAGE BY MICHAEL CAPLINGER AND MICHAEL MALIN, MSSS; DATA FROM NASA/JPL MARS GLOBAL SURVEYOR MISSION, MOC AND MOLA SCIENCE TEAMS; BOTH SPACECRAFT BY NASA/JPL

There's no doubt that many Mars scientists, given free rein, would choose other sites (Nathalie Cabrol is an exception—she and Grin have lived, breathed, and dreamed Gusev for years, and the idea of going there lights up her face). But that doesn't make them any less enthusiastic about the rover missions. Given the sites, it's hard to imagine the rovers not making striking discoveries about Mars's distant past. There's even a chance that they could learn something about the icy present too. Some people think there may be subsurface ice right at the equator. Who's to say that some trace of it might not be found?

This is all, in a way, secondary. When asked why he's so excited about the rovers, Phil Christensen's geologist co-worker Jim Rice looks amazed anyone could ask such a thing: "They're going to Mars, man." Equipped with yet more of Christensen's infrared mineralogy-at-a-distance spectrometers, the rovers will be able to spot the most interesting rocks for analysis in a landscape, trundle over to them, and learn what they're made of. It's as close to putting a geologist on Mars as you can currently get, and for everyone involved that's enough.

Spirit, Opportunity, and Beagle 2 can never crack all of Mars's mysteries. Targeted at the equator, they can't examine processes at work in the midlatitudes. And they won't be able to sort out questions of Mars's climate cycles or dig deep enough at suitable locations to rule liquid water in or out. But they will undoubtedly deepen the relationship Earth's scientists have with Mars.

If all goes well, the teams running the rovers will come as close as they can to actually living on the planet. Their lives will follow Martian clocks and calendars. Their questions will be Martian questions, their problems Martian problems. They won't taste the pervasive dust or feel the deep chill of the air—but it's a fair bet that, late in the night, they'll half believe they do.

Will that sense of place matter? Maybe not. A rich stream of data continues to arrive from spacecraft in orbit and will increase further with the addition of Europe's Mars Express this winter. In 2005 NASA's Mars Reconnaissance Orbiter (MRO) will add data from yet more instruments including HiRISE—a camera that will pick out details as small as 30 centimeters.

I'D SEND IT TO...

SIX SCIENTISTS EXPLAIN WHERE THEY WOULD LAND A ROVER—AND WHY



Phil Christensen, geologist, Arizona State University.

Somewhere cold enough for snow and ice but warm enough for it to melt, such

as the small crater at 43° south (shown on pages 14-15). Snow—and the gullies it formed—may hold clues to past climate.

Agustin Chicarro, Mars Express Project Scientist.

Wrinkle ridges in the plains south of Valles Marineris.

Such ridges indicate that the planet shrank as it cooled, a clue to the tectonic history of Mars. "I'd love to go there myself," says Chicarro.



Maria Zuber, geophysicist, MIT. Terrain near the south pole, where Mars Polar Lander was headed in 1999. A look at the layers of dust and dry

ice will reveal the timescale of climate cycles.

Michael Malin, geologist, Malin Space Science Systems. Sediments deposited by an extinct lake in Holden crater. "There are layered

sedimentary rocks on the southwest floor of the crater that are easily accessible and unusually similar to terrestrial landscapes. The layers record the history of Mars."



Bruce Jakosky, astrobiologist, University of Colorado. The

edge of the north polar cap. Drilling several feet down might reveal ice that was liquid water

tens of millions of years ago, greatly improving the outlook for finding evidence of life on Mars.

Michelle Minitti, petrologist, Arizona State University.

"Some blatantly igneous place like the top of Olympus Mons." Rocks on the solar system's biggest volcano could explain

Mars's interior workings, and how volcanism shaped the surface.



Somewhere in all this information may lie clues to help scientists cut through much of today's confusion. But in the face of such a torrent of data, it will be helpful to have solid rock to stand on. The landers can provide that sure footing by showing us what a couple of places on the planet are really like. What's more, the wheel-on-rock experience gained from Spirit and Opportunity will make it possible to develop future rovers capable of tackling the most promising new sites the orbiters discover.

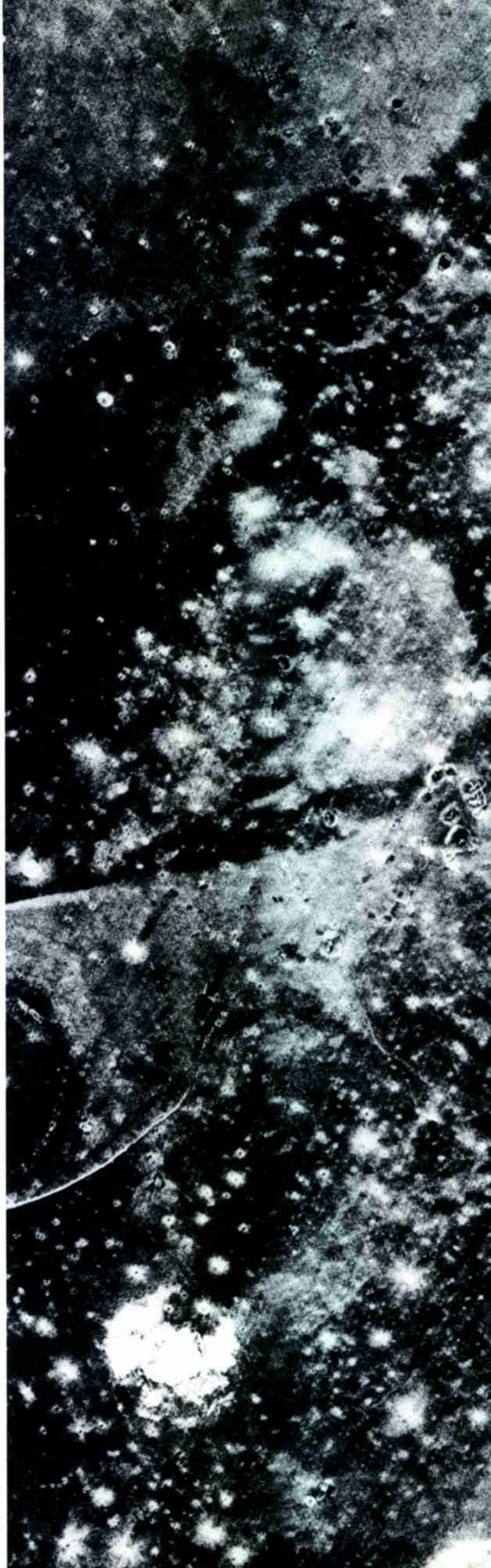
But perhaps the most important new frontier in Mars exploration is the sense of time. When MRO gets to Mars, MGS will have been in orbit for nearly ten years, and there are plans for two more NASA missions this decade. As the missions add up, so does something greater than the sum of their individual achievements: a composite record of Mars's three-dimensional surface stretched over the fourth dimension of time. If the key to Mars is the way that it changes, the key to understanding is constant inspection. And surely no planet other than the Earth has ever enjoyed such continuous attention.

You can't help thinking that Galileo, arguably the first planetary scientist, would have approved. Before him, doctrine held that the heavens were perfect and unalterable. Galileo discovered that in the heavens, as on Earth, things didn't stay the same and said that change was everywhere—and that it was good. A changeless Mars, like a changeless Earth, would be so dull as to merit no respect: "If at the time of the flood the waters which covered [the Earth] had frozen, and it had remained an enormous globe of ice where nothing was ever born or ever altered or changed," he wrote, "I should deem it a useless lump in the universe."

Today Mars looks a lot more like a globe of ice than it ever has before. But it also looks like something shucking that ice away, something moving on, something undergoing change. Whatever else Mars turns out to be, it won't be a useless, changeless lump in the universe. □

WEBSITE EXCLUSIVE

Do you believe there's life on Mars? Vote in our poll and join the discussion in Forum. Next, zoom in on Mars's surface, exploring the terrain rock by rock. Then experience the Sights & Sounds of "A Mars Never Dreamed Of." You'll also find animation of future Mars landings and a listing of related websites at nationalgeographic.com/magazine/0401.





A NEW VIEW

Mars's northern plains look like a starry sky in this mosaic of THEMIS infrared views. White signifies rocky material that holds heat in the frigid darkness. The surrounding patches of black indicate quickly cooling plains of sand and dust. These clear temperature delineations mean rocks have not yet been eroded, buried by dust, or scattered by wind—evidence of a surface just millions of years old on a planet that formed 4.5 billion years ago. This entirely new way of looking at Mars yields clues to the forces that are shaping it—right before our eyes.

NOEL GORELICK, ASU; NASA/JPL
180 KM x 180 KM

HIMBA

CONSULTING THE PAST

DIVINING THE FUTURE



Bodies glowing with butterfat and red with ocher, Himba women in northwestern Namibia are sought by tourists looking for “traditional” Africa. But Himba ways are changing fast as these herders negotiate their place in a young nation, independent since 1990. While most of the women still wear skins, they are beginning to vote, send their children to school, and count wealth in cash as well as in cattle.





Though dancing Himba women appear untouched by outside influences, their husbands and sons, who have more chances to earn wages in towns, are likely to mix Western clothes with traditional garb.



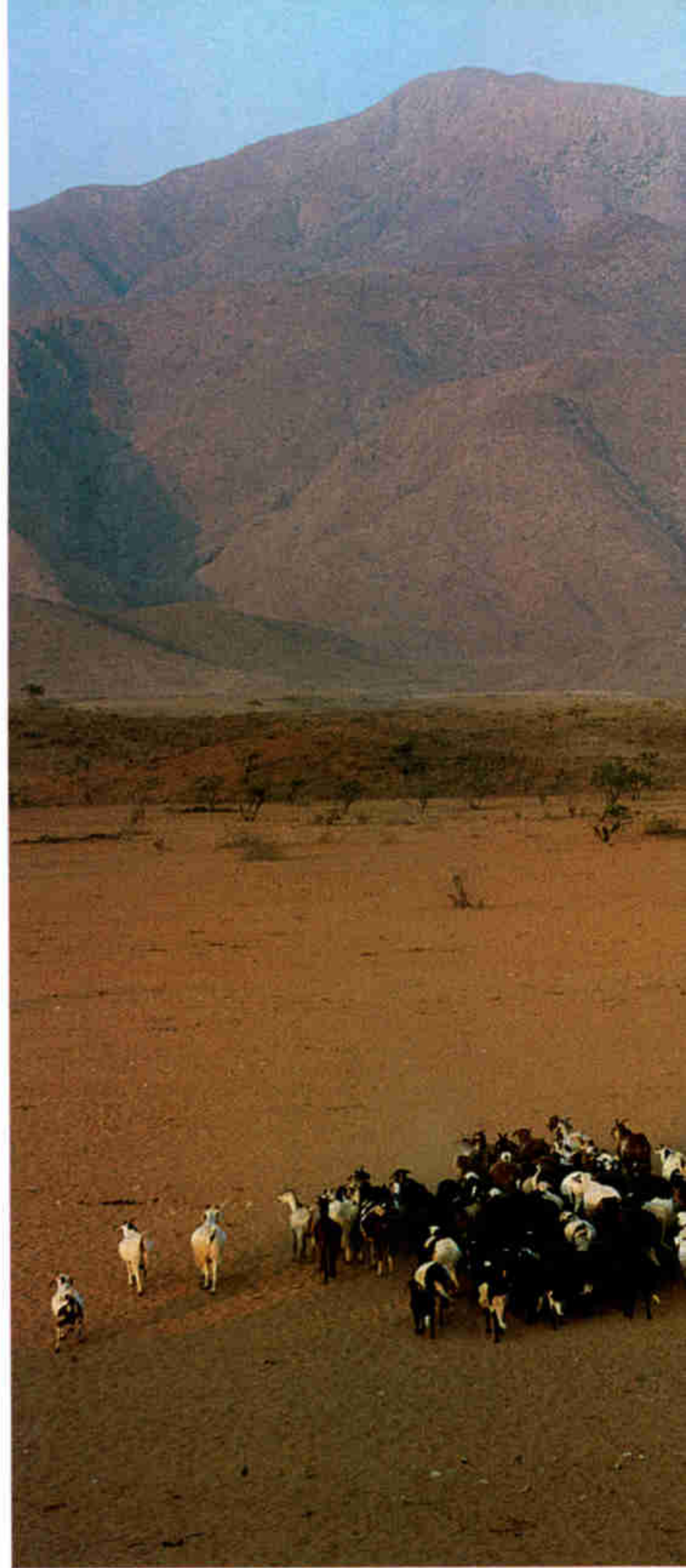
Women hold on to Himba dress in part because the larger world of jobs and politics remains closed to them, says anthropologist Margaret Jacobsohn.

BY KAREN E. LANGE
NATIONAL GEOGRAPHIC WRITER

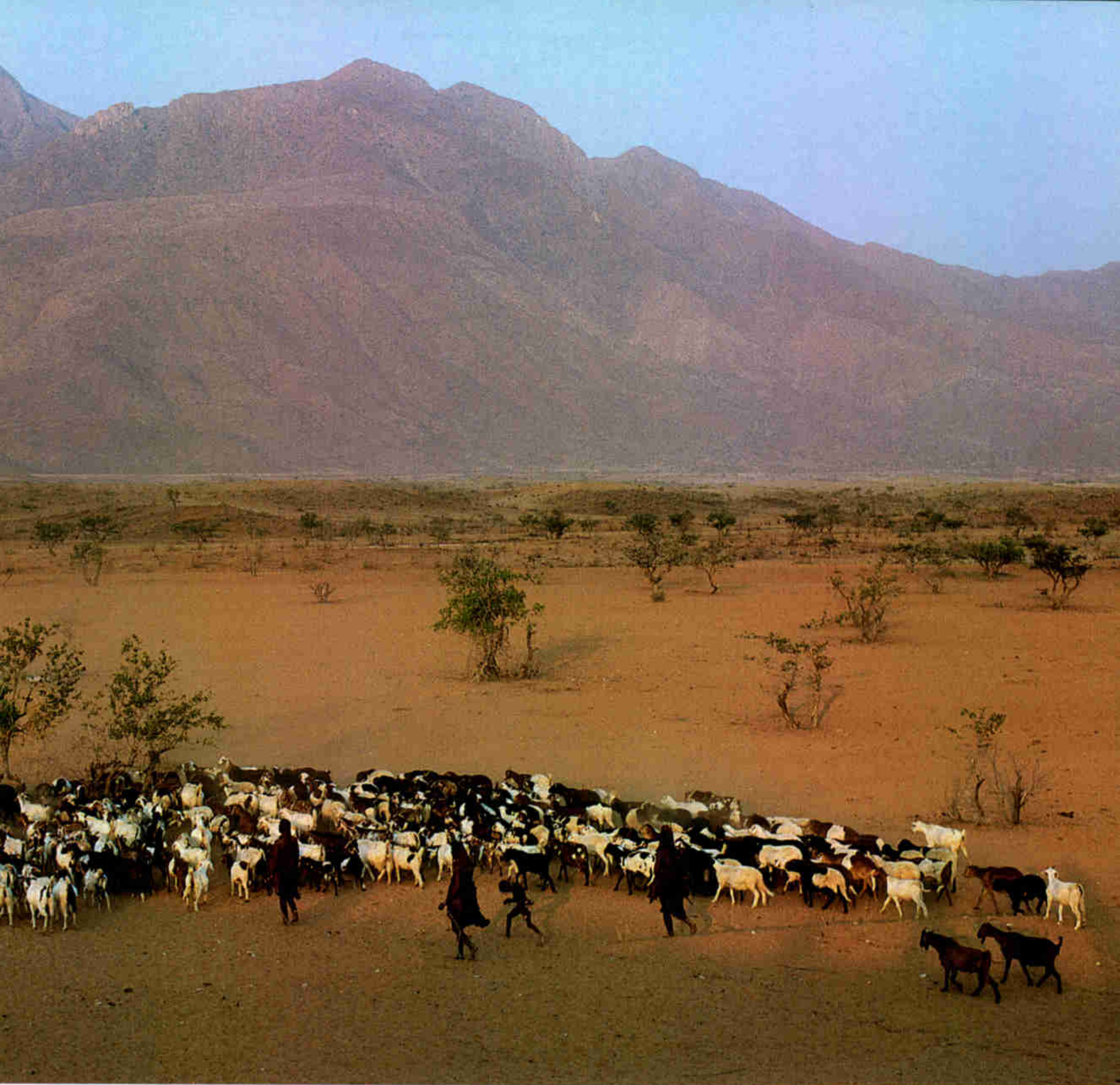
PHOTOGRAPHS BY
CAROL BECKWITH AND
ANGELA FISHER

When drought and war struck Namibia in the 1980s, it looked as if the culture of the indigenous Himba people might disintegrate. Ninety percent of Himba cattle, the center of their economy and identity, died. Some families left for Angola. Lacking any other means of survival and desperate for cash, a number of men joined South Africa's army in its fight against guerrillas seeking Namibian independence. Unable to feed themselves, Himba flowed into the town of Opuwo for relief food, settling in slums of cardboard and plastic sacks.

But the estimated 20,000 to 50,000 Himba, long among Africa's most prosperous herders, are resilient. In the 19th century those in Namibia survived cattle raids by marauding ethnic groups from the south.



Most fled into Angola, joining with the Portuguese military and forming their own armies of raiders. Eventually many returned to Namibia. Starting in the 1920s, South African rulers confined them to a prescribed "homeland," officially forbidding them to trade, graze livestock freely, or garden and gather wild plants along the Kunene River. Yet they endured—even if at times it meant eating the hides they slept on.



With the peace and good rains that came to Namibia in the 1990s, the Himba rebuilt their herds and, working with international activists, helped block a proposed hydroelectric dam that would have flooded ancestral lands along the Kunene. They also have benefited from new opportunities provided by the government of independent Namibia—mobile schools where Himba children learn English, and conservancies that give Himba control of wildlife and tourism on their lands. Vengapi Tijvinda, a grandmother in her 50s, lived through this rebirth. In the 1980s she was making baskets for tourists near Purros. Now she has returned to farming and raising goats and cattle: “Life is still the same, but the children can read and write. I am a member of [a] conservancy, and we have tasted game meat again.”

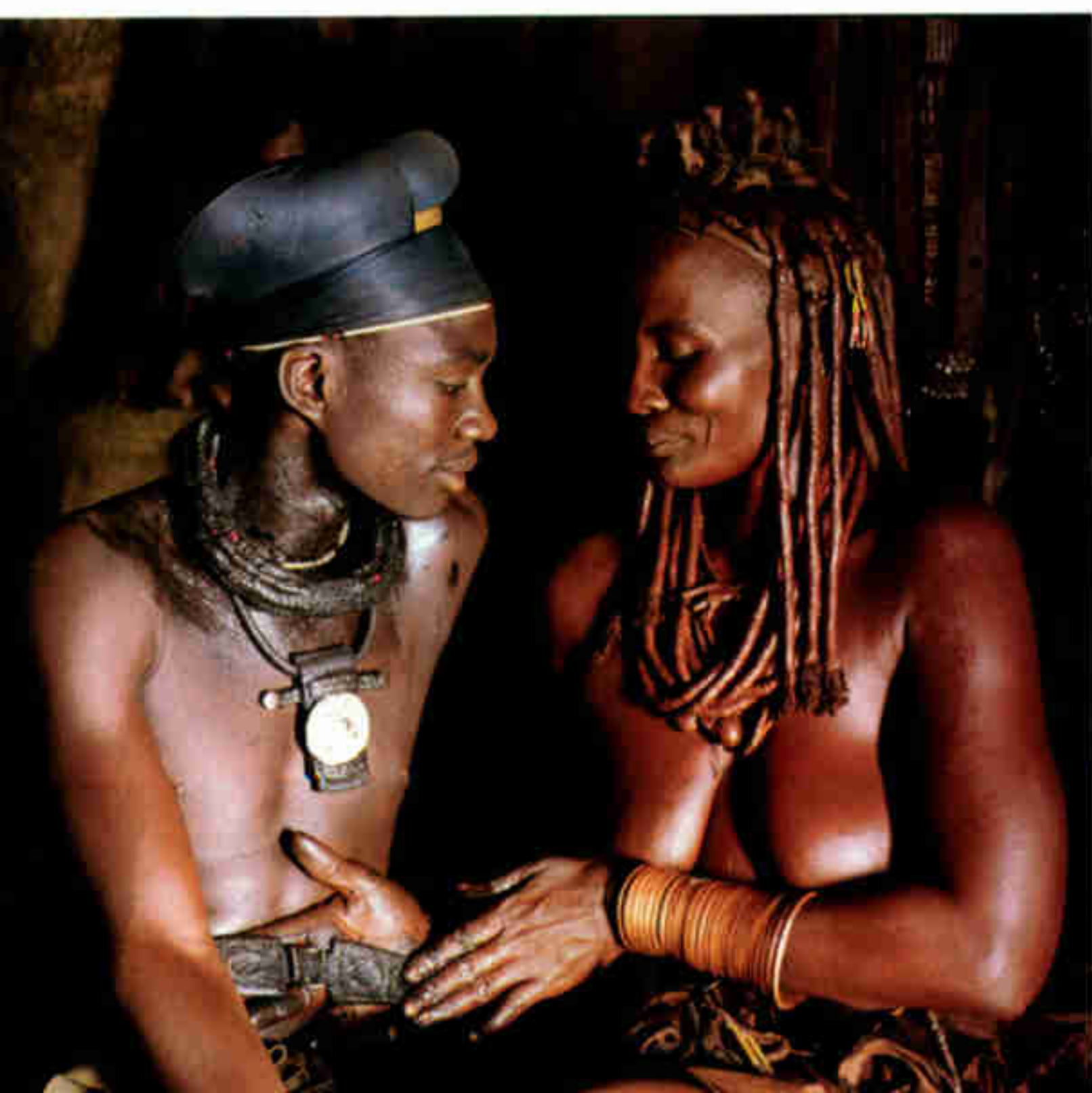
Hardy goats sustained the Himba during the 1980s drought, when the herders lost most of their cattle. Even now goats remain important. Lacking the ritual significance of cattle, they can be killed for meat or sold for cash.





MOTHER TO DAUGHTER

Crowned by a lambskin headdress—its rolled leather “horns” standing for the fertility of women and cattle—a mother dandles her baby. Despite the increasing influence of the cash economy, Himba mothers remain highly honored for their life-giving power. “Money does not give birth,” the Himba say. Girls become full adults only when they have children. At marriage a woman leaves her father’s homestead to live with her husband’s family, but she briefly returns to her mother to have her first baby. Rope wigs (above, bottom) worn by girls about to start menstruating and ceremonial slings (top) used by mothers to carry infants on special occasions are passed down from generation to generation within a line of women, signs of the potency of the matrilineage.



FAR-FLUNG TIES



Plaiting shoulder-length braids that signify adult status brings together women of several homesteads. Through such gatherings, women forced by marriage to move apart and begin life anew in different villages maintain contact, strengthening social networks crucial to survival in a drought-prone region. To mark the transition from her father's to her father-in-law's homestead, a bride will wear a special headdress (opposite, top) with a sheepskin veil that is rolled down when she leaves her childhood home and lifted when she arrives at her new house. For a groom, who on his wedding day will begin to bundle his hair under a cloth covering, marriage brings no change in residence but a huge change in social position. He becomes a full member of his father's patrilineage, able to establish his own homestead. Now he will draw on a web of relatives. Through his mother's family he will inherit cattle. Through his father's he will inherit access to land, water—and ancestors, who serve as intermediaries between the living and God.



A cool dome of branches plastered with cattle dung shelters children in a dry-season camp. To feed their livestock where little water flows above ground, Himba families move as many as ten times a

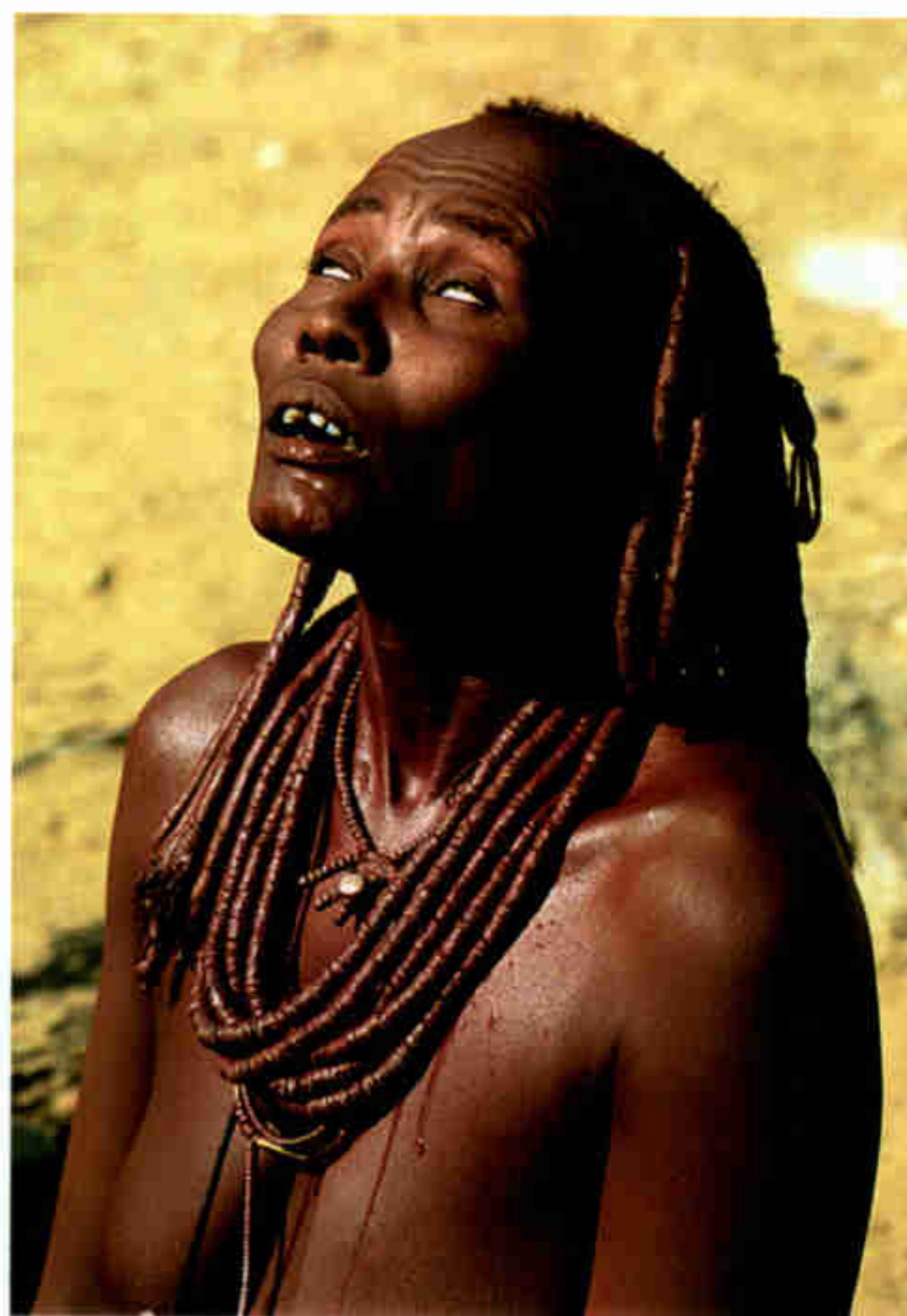


year. Just before the rainy season, when most grass has been eaten or withered, they return to homesteads in greener river valleys, where grazing usually remains good even in the late dry season.

Women roar in the dust like lions during a dance that portrays a new type of healing that is growing in popularity (below). Himba women believe that spirits of dangerous animals or the dead can enter their bodies and afflict them with physical illnesses—leading them to call on female healers, who perform exorcisms helped by other women. Holding a healer’s calabash, one woman grapples with a “possessed” dancer (opposite, top). Eyes rolled back (opposite, bottom), another woman falls into a trance. Healers enter this state to draw spirits out of the afflicted. Anthropologist Jacobsohn sees such group trancing as a means for women to deal with unprecedented change—an influx of tourists, alcohol, children going to school, men working in towns for wages—that has robbed them of authority and left them uncertain about their role in society. “It’s a way of handling conflict and stress. And conflict and stress have increased in the past 20 years.”



CASTING OUT EVIL





FEMALE BONDING



A group trance may start as a party around a fire (above and opposite), with drinking, dancing, and plenty of meat, then shift to a healing, where women struggle with supernatural forces. Usually the otherworldly bellow of a special drum reserved for trancing calls every woman within hearing. They sit around the fire, swaying to the beat. “They go on and on and on,” says Jacobsohn, who has witnessed such sessions. “Like teenagers at a rave.” Slowly the women fall into trances. Some may suddenly exhibit possession. “I have

WEBSITE EXCLUSIVE

Watch Himba ceremonial dancing and drumming, enjoy a Web-only photo gallery, and find related resources at nationalgeographic.com/magazine/0401.

seen people become three times as strong.” Men looking on are deferential. If the women order them to do something, they quietly comply. For a night, at least, the women assert their power in the face of a future they cannot see and a present that challenges the past. □





PATAGONIA

LAND OF THE LIVING WIND

Manes rippling, horses roam free in Patagonia, the Big Sky country of southern Argentina and Chile—where granite peaks crown glacial lakes, and the dreams of new pioneers still have room to grow.

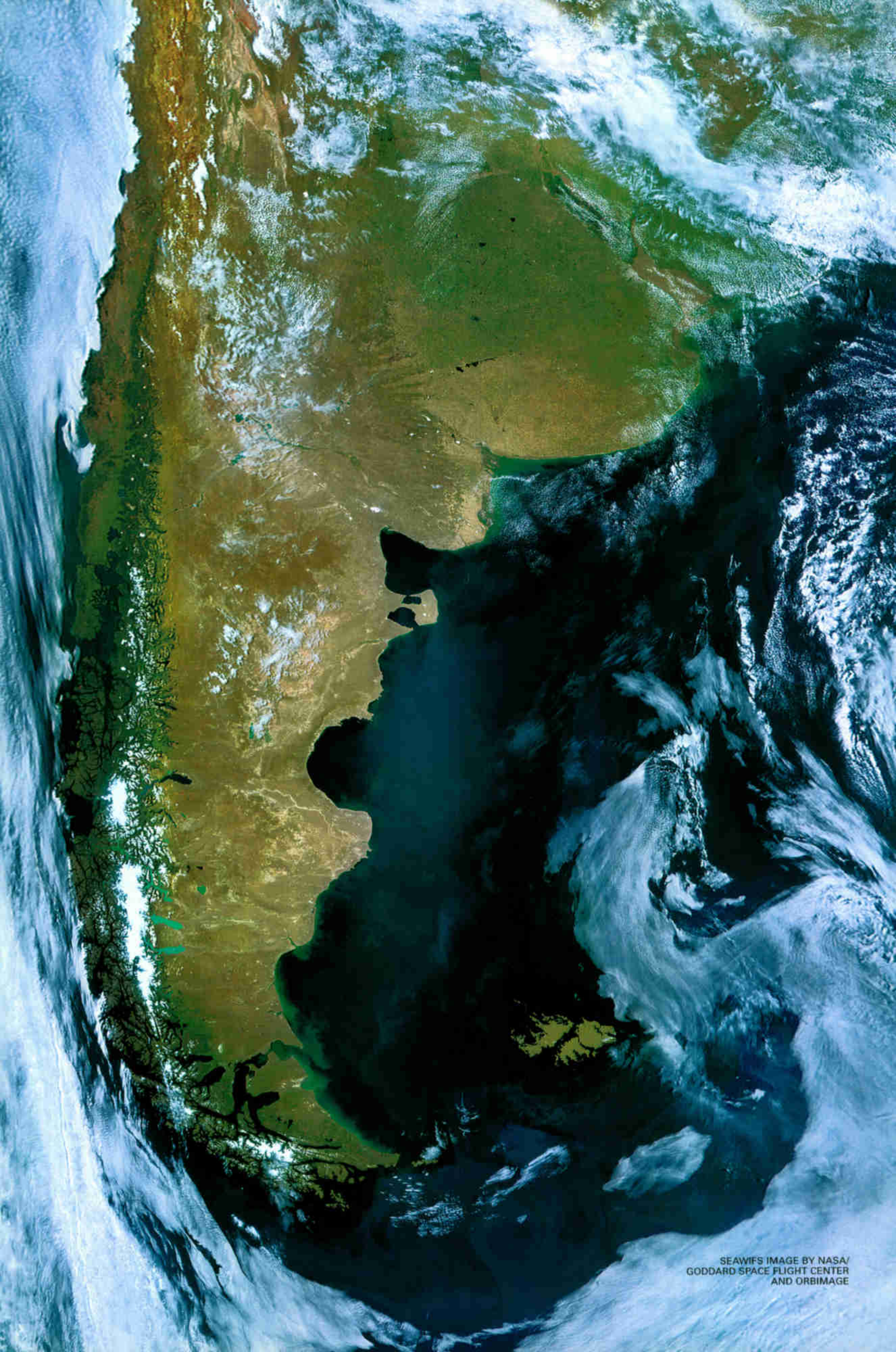


GOOD PROSPECTS

A battered sign points to a mine gone bust at a deserted claim in Chubut Province. Yet fortunes in minerals such as oil and gold still await the lucky on this arid frontier. Amid seaborne winds—the roaring forties and furious fifties—named for southern latitudes, corporate ranchers are also discovering a wealth of opportunity. Reclusive celebrities and ecotravellers find the unspoiled wilderness priceless.







SEAWIFS IMAGE BY NASA/
GODDARD SPACE FLIGHT CENTER
AND ORBIMAGE

BY SIMON WORRALL
PHOTOGRAPHS BY PETER ESSICK

The wind chased me everywhere I went in Patagonia.

It clogged my sinuses and sent the Jeep slithering across the gravel roads as though on ice. Birds flew backward. Trees grew horizontally. The wind was a living thing. It could be violent, punching holes in glass windows or sending spirals of dust rising above the flat, dry steppe like miniature tornadoes. On a plateau above the Santa

Cruz River Valley I got out of the Jeep to take a photograph, and a blast of wind wrenched the door out of my hand, bending it backward with such violence that it sheared off the two welded brackets holding the door to the chassis. At other times the wind had a feather touch. At a ranch near the Valdés Peninsula, on the Atlantic coast, I watched as the wind caressed a piece of paper, moving it about on the ground in a circle like a magnet moving a ball bearing. In Puerto Deseado I lay awake all night listening as the wind turned my hotel into a riotous orchestra. Doors rattled like snare drums. A gap under the corrugated roof wailed like a flute. The ventilation grill in the bathroom emitted a steady drone like a bagpipe. All night the wind played its wild fugue, dropping to pianissimo lulls, then rising to frenetic crescendos.

Until recently this vast, sparsely populated region in the far south of South America was a byword for remoteness—*finis terrae*, the uttermost ends of the Earth. Never a country or a state but rather a loosely defined region shared by two countries, Chile and Argentina, Patagonia is generally defined today as everything south of the Río Colorado and the eastern portion of the

Río Bío-Bío. But there's no overarching sense of Patagonian identity, and everyone I met had a different idea of the place. "Patagonia," said one sheep rancher in northern Tierra del Fuego, brandishing a sizzling lamb chop in the air, "is everywhere you can taste this!"

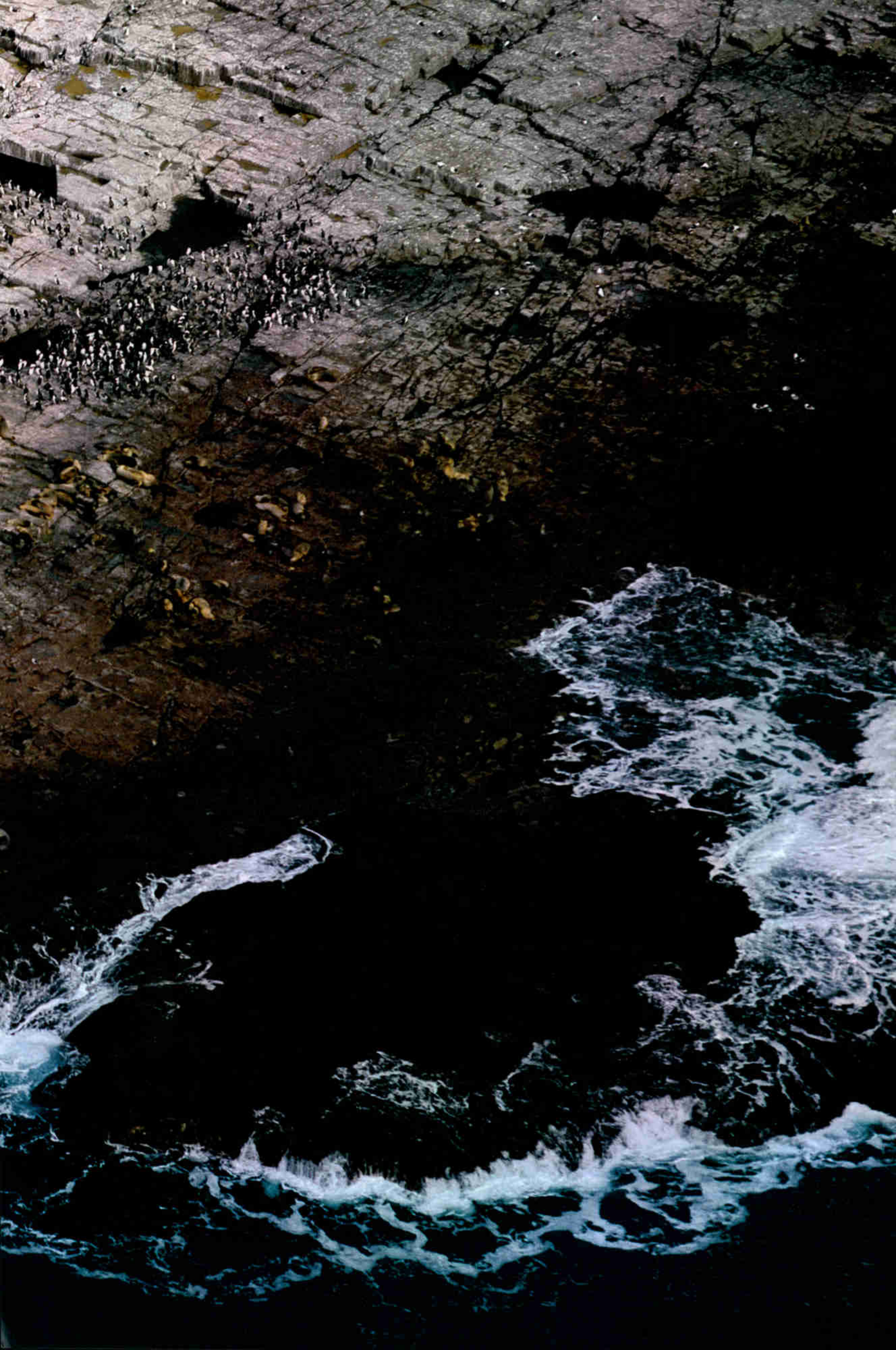
Because of its remoteness and inaccessibility, Patagonia has always been, like Timbuktu or Shangri-la, a place of myths and legends. Bruce Chatwin, the British explorer-writer, thought he had found the origins of the unicorn myth in a cave painting in southwestern Patagonia. (It was actually a rare species of Patagonian deer, known as a huemul.) Now new myths are being born: To much of the world Patagonia is a clothing company, not a place. For adventurers it's the planet's "edge" destination—nature in its wildest form. For corporations it represents a storehouse of natural resources—oil, gas, gold, and fish. As globalization pulls more and more of the world into its magnetic orbit, and communications overcome distance, Patagonia is moving from the mythical margins toward the center of 21st-century reality.

All this is feeding new regional pride, and in

TEEMING SHORES

Cold waters swirling in from Antarctica support a boundless variety of creatures along Argentina's rocky Atlantic coast. Conservation efforts include a ban on hunting sea lions, which join cormorants and other seabirds here on the tide-scoured Punta Clara peninsula.







LAND'S END

About twice the size of France—but with fewer people per square mile than Western Sahara—Patagonia remains remote more than a century after Europeans settled in. Never precisely defined, it stretches from about the Río Colorado and part of the Bío-Bío to the tip of the continent.

my travels I often heard the phrase *NYC—nacido y criado*, which means “born and raised” Patagonian. The election in May 2003 of Néstor Kirchner, the governor of Santa Cruz Province, as Argentina’s president—its first from Patagonia—has further boosted the region’s growing self-confidence.

Of all the changes blowing through Patagonia, though, none has had greater impact than the shifts in ownership and use of the land brought about by the collapse of the huge sheep farms, or *estancias*, of the Argentine tableland. Stretching nearly 1,500 miles from the Río Colorado in the north to Tierra del Fuego in the

south, this immense arid wilderness—the steppe—is the heart of Patagonia. Its culture and economy were built on the sheep’s back. But since the 1970s falling wool prices and desertification caused by overgrazing have brought the industry to its knees. Hundreds of *estancias* have gone out of business, while others have been sold to wealthy foreigners. Nearly one-sixth of Argentine Patagonia now belongs to 350 foreign owners, many of them Americans.

“We used to have 12,000 sheep, 90 horses, and a few cows for milking,” said Joan “Petty” Nauta in her ringing Scottish accent as we sat drinking tea in the kitchen of Estancia Telken near the town of Perito Moreno in Santa Cruz Province. Twice as big as New York State, with a population of only 200,000, Santa Cruz is the historical epicenter of the Patagonian sheep industry. “Now we have less than 3,000.”

Set in the lee of a line of hills rising toward the Andes, Telken is, like all *estancias* in Patagonia, an oasis of green in a biscuit-colored wilderness. It had taken me two days of bouncing and sliding along potholed gravel roads to reach Perito Moreno from Puerto Madryn on the Atlantic coast. For hours as I chased the horizon across the empty expanses, I saw no cars or buildings—just an ocean of grass and *mata negra* bushes, a dome of blue sky, and the occasional grubby sheep. Sometimes a gaucho on horseback would appear, with a pack of yapping sheepdogs at his heels: a lone figure in an infinity of space. The landscape reminded me of the Australian outback. But instead of kangaroos, there were herds of guanacos, shy, llama-like animals found throughout Patagonia. At my approach they would bolt away, hooves flying, their marmalade and white fur shining in the sunlight. Gas stations were often hundreds of miles apart, and I marveled at the skill of the pump attendants, who managed to get the very last drop into the tank, withdrawing the nozzle a fraction of an inch at a time until the little metal flap at the top of the tank’s stem snapped shut.

Now as I sat talking with Petty, it felt good to be out of those great spaces for a while. The kitchen is the nucleus of a Patagonian *estancia*, where people gather to eat and relax—and get out of the wind, which even in summer can chill you to the bone. So Telken’s ornate iron stove is kept going all day. By the door was the

"PATAGONIA," SAID ONE SHEEP RANCHER IN TIERRA DEL FUEGO, BRANDISHING A SIZZLING LAMB CHOP IN THE AIR, "IS EVERYWHERE YOU CAN TASTE THIS!"

estancia's only link with the outside world, a VHF radio. From the garage came the *toc-toc-toc* of a diesel generator, the heartbeat of Patagonia, which provides electricity for part of the day.

"My father came here from New Zealand in 1909," said Petty, a short, vivacious woman with cropped dark hair and the sort of soft white skin, sprinkled with freckles, my English aunts have. Outside, a row of blue and pink lupines blazed in the sunlight. "Mother was Argentine-Scottish, and the first thing she did when her husband brought her here was to make a garden." She paused. "We were never stinking rich," she said, lifting the cockerel-shaped cozy from the teapot to pour another cup. "We had our better years and our tighter years. But we never lacked for anything."

At the high point of sheep farming, from 1930 to 1970, Santa Cruz carried seven million of Patagonia's sixteen million sheep on more than a thousand estancias. Then the decline began. For many estancias the final blow came on August 8, 1991, when Mount Hudson, a volcano across the border in Chile, erupted. In one week, aided by a strong westerly wind, it spewed millions of tons of ash over a swath of Santa Cruz from the Andes to the Atlantic. The ash was like an abrasive, grinding the sheep's teeth to nubs and clogging their watering holes. In the winter after the volcano, Telken lost more than half its flock.

It was a story repeated all over Santa Cruz. Of the thousand estancias that had made it the woolshed of Patagonia, only 600 survive today. Many have simply been abandoned, their kitchens filled with ash, their furniture looted. Telken keeps going because, like a growing number of estancias, it turned to tourism—offering a modest, Patagonian-style dude ranch experience.

"We're lucky because we're near route 40," said Petty, pointing out of the window toward a ribbon of gravel that winds down the edge of

the Andes. "But some estancias are 50 miles from the nearest road, and unless they're in the Andes or have some special attraction, who's going to travel that far?"

Distance and climate have always been the supreme arbiters of life in Patagonia. Every few hundred miles I came across roadside shrines to Difunta Correa, a saint revered by local people although not recognized by the Catholic Church. Legend has it she died of thirst in the early 1840s while following her conscript husband's battalion across the desert, but that when she was found, the baby at her breast was still alive. For the people of Patagonia these shrines are beacons of hope and symbols of survival in a hostile land. Some are elaborate concrete structures, but most are no more than crudely fashioned metal boxes about the size of a dog kennel placed at the side of the



RANGE ROVERS

Spruced up for a rodeo in Las Lajas, gauchos sport the classic berets, baggy trousers called bombachas, and braided leather lassos that characterize their enduring culture. Breaking horses, branding cattle, and herding sheep come easy to these men. Riding out the economic ups and downs of modern ranching is a bit rougher.



SHEAR RUINS

Fleece gritty with ash litters an abandoned shearing shed in Santa Cruz. The 1991 volcanic eruption of Mount Hudson shut down this sheep ranch and hundreds of others in the province, devastating the industry that once defined Patagonia. "It would be tough to start up again," says Josefina Ortolá, who owns a neighboring property. "Foxes and pumas control the fields now."



WIDE-OPEN SPACES AND BREATHTAKING SCENERY HAVE MADE PATAGONIA A FASHIONABLE NEW FRONTIER: MONTANA AT BARGAIN-BASEMENT PRICES.

road or wedged into some boulders. Inside there is always a figurine of Difunta Correa—a dark-skinned young woman with long black hair and a red peasant's skirt, lying on her back nursing a baby. Travelers leave her simple offerings: candies, a few cigarettes, a can of soda. In one shrine I found a pair of cleats, a totemic object in soccer-mad Argentina. But the most common offering is that most precious commodity in Patagonia: water. At one shrine I counted more than 200 bottles of mineral water.

"The most important thing is the amount of rain," said Leopoldo Henin, the 37-year-old manager of La Coronel, an estancia near the coastal town of Puerto San Julián. He was pointing at a satellite image on the wall of his office, an old zinc-sided building that had been handsomely restored and painted in the red, white, and green of Italy. Outside, a 30-foot-high microwave tower soared into the immaculately blue Patagonian sky. "We have to have at least 240 millimeters [almost nine inches]. Much depends on that. In a dry year we get very little grass."

The image showed a cluster of eight estancias in a steep-sided valley. They formerly belonged to the San Julián Sheep Farming Company, one of the Anglo-Argentine firms that traditionally dominated the sheep industry. Then, in 1996, after years of decline, they were bought by the Italian fashion magnates Luciano and Carlo Benetton. "We knocked many of the old buildings down," said Henin. "We also spent a lot of money restoring others."

By forging the separate properties into a single 830,000-acre unit and investing large sums of money in new roads, a microwave phone system, and a fleet of vehicles, the Benettons have been able to do what no local rancher could afford: create an economy of scale that generates bigger profits with a smaller workforce. La Coronel is now the largest, most up-to-date estancia in Argentina. "Our property is roughly 60 miles long and 20 miles wide," said Henin. "All the shepherds' huts have indoor plumbing and VHF radios."

The Buenos Aires-born Henin could have stepped out of a Benetton catalog, with his shining leather riding boots, Australian bush hat, and bombachas—baggy trousers worn by gauchos. But the razor-sharp gaucho's knife in a cowhide sheath he had made himself and a rack of well-oiled guns—including a .44 pistol, an antique Winchester, and an Argentine Army assault rifle—suggested he was not just dressed for the part. "For foxes and guanacos," he said irritably, when I asked why he needed an assault rifle. "Or journalists."

Henin's wariness is understandable, given the wealth and celebrity of La Coronel's new owners. But it's at odds with Patagonia's open and neighborly society. Traditionally estancias were the center of a rich nexus of social relationships linking town and country. Estancia owners would come to town to buy kerosene or rice, baptize their children, or dance the tango. Townspeople would ride or drive across estancia lands to camp or have barbecues. Fences were to keep sheep in, not people out.

Not at La Coronel. Instead of the simple Australian-style sheep gates found throughout Patagonia—basically a length of fencing wire stretched across the road—La Coronel is ringed by steel gates with electronic entry codes and signs emblazoned with words alien in Patagonia: *Propiedad Privada*, Private Property. Fuel and provisions are trucked in by distant wholesalers. The produce is trucked out, into the global economy, without even passing through San Julián. "The wool is sent to Trelew in northern Patagonia for washing and combing," said Henin, leading me out to the *galpón*, or shearing shed, a long white building with a bright red metal roof. "Then it's sent to Italy and China."

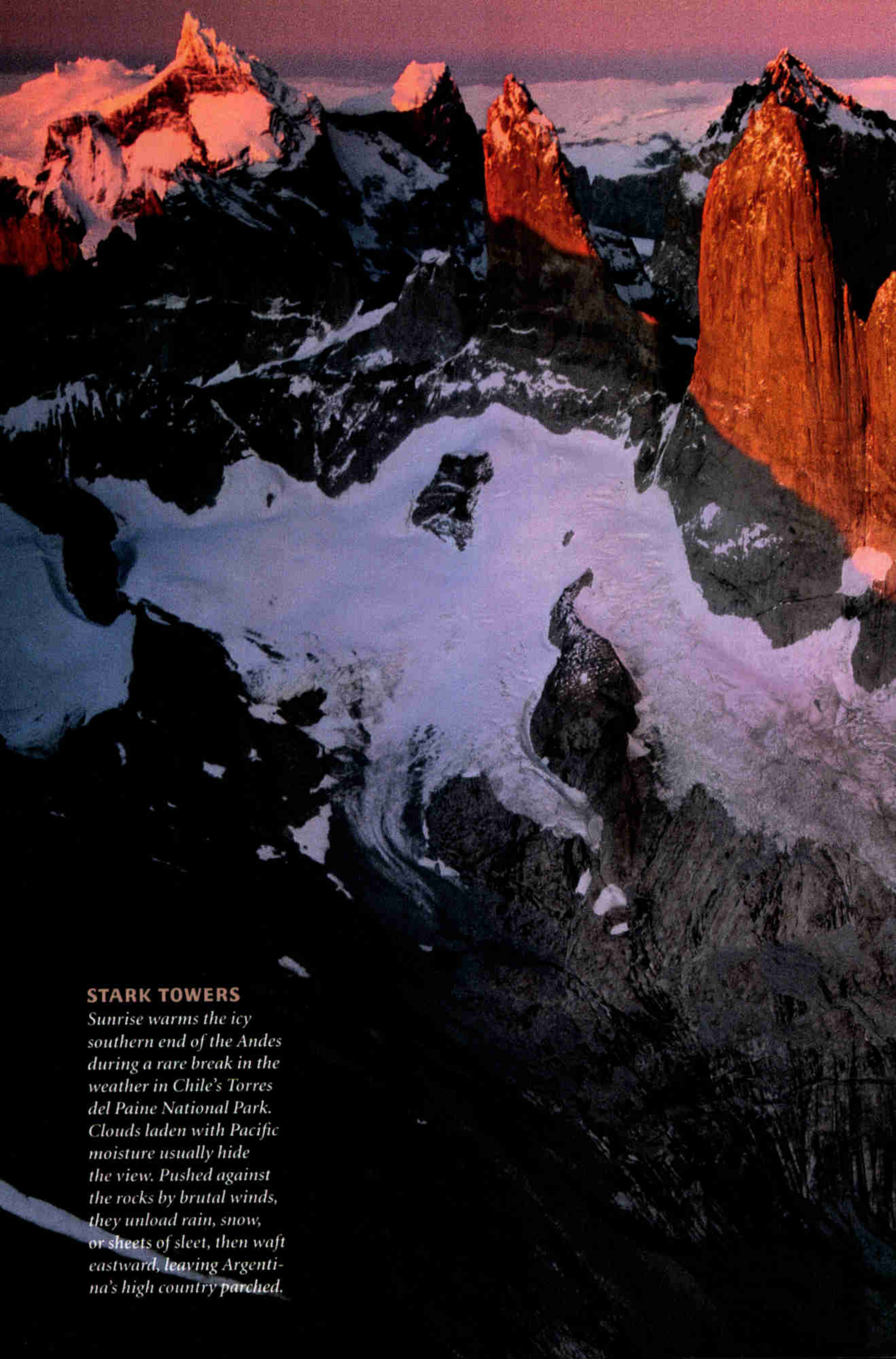
On a table in the center of the shed was a pile of Corriedale-merino wool fleeces—dense, oily, and smelling pungently of sheep. Patagonian wool is highly sought by fashion designers like the Benettons who can achieve more subtle dyeing effects with it than with any other wool. As I plunged my hands into one of the fleeces,



LIFE IN ISOLATION

From an outpost called a puesto (above), hired hands tend to far-flung grazing in Río Negro, where a single ranch can stretch for several hundred thousand acres. "I can fly for more than three hours and see just a few of these places," says bush pilot Javier Adem. Residents of this empty steppe find bare comforts in towns like Los Altares: one bar, one gas station, one telephone.





STARK TOWERS

Sunrise warms the icy southern end of the Andes during a rare break in the weather in Chile's Torres del Paine National Park. Clouds laden with Pacific moisture usually hide the view. Pushed against the rocks by brutal winds, they unload rain, snow, or sheets of sleet, then waft eastward, leaving Argentina's high country parched.



I thought how miraculous it was that something so soft and delicate should come from a landscape so harsh and unyielding.

“Our aim is to maintain a constant level of production,” Henin continued, slapping a pile of plastic folders onto the table. In neatly typed columns was a statistical breakdown of production for the eight years since the Benettons had bought the estancia: the number of lambs, the volume of wool, even the length of the grass in each paddock. By rigorously controlling the number of sheep, the Benettons are also trying to avoid the cycle of overstocking and ecological degradation that has blighted much of the rest of the steppe. “Very few estancias can do this,” said Henin proudly. “It’s a complicated, expensive business.”

It seems to be working. Wool yields at La Coronel have risen by 20 percent. And as if proving the maxim that to those who have, more shall be given, the price of wool has also made a dramatic recovery. Eight years ago when the Benettons bought La Coronel, the price of processed wool stood at a record low of 30 cents a pound. Today it has jumped to three, even four, dollars a pound. Inspired by these numbers, the Benettons now own five estancias in different parts of Patagonia, making them, with more than two million acres, the largest landowner in the region.

As I drove away from La Coronel, a smudge of clouds stretched across the horizon. Rain was falling. But the heat rising from the steppe was so intense that the drops evaporated before they reached the ground. Lack of rain, the poverty of the soil, and the winds that roar across Patagonia at up to 150 miles an hour—stripping mountains to bare rock, carrying topsoil away, and scything vegetation flat—have kept the region poor. Most towns are rough-and-ready frontier-style settlements consisting of a few dirt streets lined with shops providing only basic necessities.

The townspeople of San Julián do their best to make the place look good. Every morning a tanker drives down the central avenue watering the rosebushes, protected from the wind by a lattice screen. But there is no disguising the fact that the town has been battered by the decline of sheep farming. “The estancias in this region used to employ about 3,000 people,” said Pablo “Poly” Walker, the director of tourism, as we passed an abandoned three-story

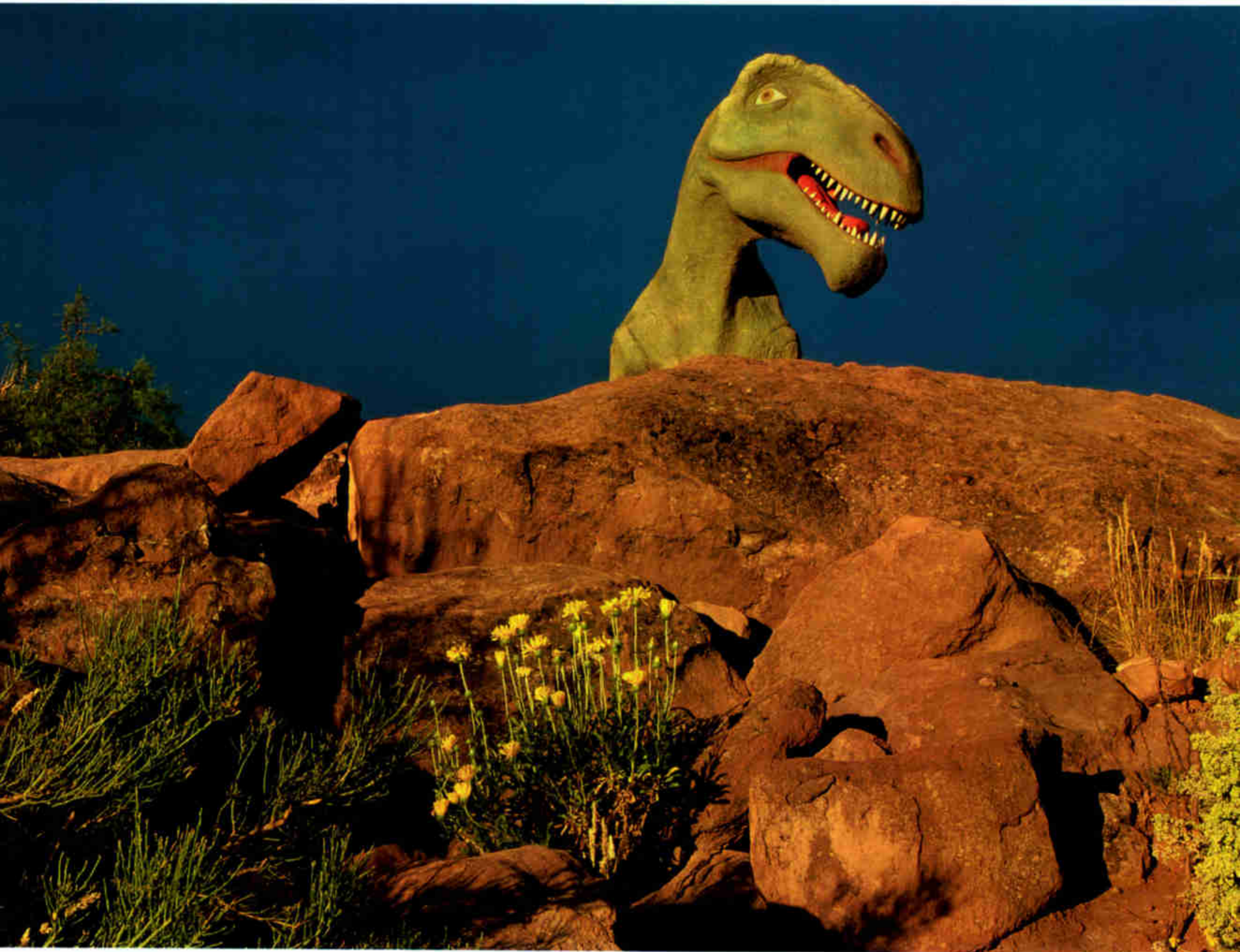
building with elegant wrought iron balconies and Doric columns—once San Julián’s largest department store. “Now there are gauchos sweeping the streets or cleaning toilets.”

Some of them may yet be back in the saddle. Growing demand for Argentine wool in other countries—one of the few benefits of the collapse of the peso in Argentina’s recent economic meltdown—combined with the recent increase in wool prices to pre-1980 levels is spurring some estancias in Santa Cruz to reopen. But too much of Patagonia’s grasslands have been turned into desert for sheep farming to fully recover. So towns are scrambling to reinvent themselves. For San Julián that means trying to put itself on the map as a tourist destination.

“We don’t have any great natural attractions, like the Moreno Glacier. What we have is history,” said Walker, pointing across the cobalt blue waters of the harbor where Ferdinand Magellan, the first European to explore this corner of South America, landed in 1520. Three centuries later, in 1834, the *Beagle* dropped anchor with the 25-year-old Charles Darwin on board.

Selling history to tourists isn’t easy: San Julián and other towns on the Atlantic must compete with the landscapes of Patagonia’s mountain west. “There’s a debate going on about what Patagonia actually is,” said Poly, as a gust of wind whipped his hair across his face. “I think the inclusion of mountains and glaciers of the Andes as part of Patagonia is just a marketing device. To me Patagonia means the steppe and the coast.” He paused. “But Patagonia has always been more of an idea than a place.”

At an estancia named Monte León, south of the city of Puerto Santa Cruz, I found an alternative vision of Patagonia’s future rising out of the dust of the sheep-farming industry. Founded by Mauricio Braun—the son of a Latvian Jew of German origin who arrived in Patagonia as a tinker in 1874 and became one of the biggest landowners in South America—Monte León was bought three years ago by a high-spirited American woman from Santa Paula, California. In her former life Kris Tompkins was the CEO of the Patagonia clothing company, but unlike the Benettons she hasn’t come to Patagonia for merino wool. And she has no plans to exploit her holdings for profit; indeed, she’s giving them away. (Continued on page 71)



WILD EXTREMES

*A life-size replica of the largest known carnivorous dinosaur—the 42-foot-long *Giganotosaurus carolinii*—offers visitors a monstrous welcome on the road to Villa El Chocón. Its inspiration, a 95-million-year-old fossil discovered near here in 1993, now rests in the town's museum.*

Measured in mere inches, sand lady's slippers pop up in a stony mountain nook.



FROZEN ASSET

The Moreno Glacier rises above Lake Argentino as a rugged wall three miles wide and almost 200 feet tall. One of 47 massive ice fields in Glaciers National Park, this grinding, groaning force of nature covers a hundred square miles.







POPULAR IDYLLS

Shadowing its mother, a baby southern right whale navigates the Nuevo Gulf before the spring migration to Antarctica. Each year 100,000 tourists visit Argentina to see these endangered giants.

Hot springs at the Copahue Volcano attract the health conscious. Named Las Maquinitas, or "little machines," for its burbling gases, a lagoon provides mineral-rich mud for skin treatments.

FOR ADVENTURERS PATAGONIA HAS BECOME THE PLANET'S "EDGE" DESTINATION— NATURE IN ITS WILDEST FORM.

"There's a wildness here that transcends all human impact," Tompkins said, recalling her first visit, in 1990, 16 years after she helped found a funky outdoor clothing company in a Quonset hut on a California beach, an enterprise that would make Patagonia a household word. We were sitting in the *chiflonera*—the word for the sheltered, porch-like extension to houses in Patagonia, which means, literally, "blast of wind." And it was the wind that impressed Tompkins on that first trip. "I had the feeling," she said, "that if you spoke, the words would come out of your mouth and be whipped behind the back of your head—and they'd end up in the Malvinas."

In 1993 Tompkins decided to move down to Patagonia because she'd grown restless in her life as CEO. "I was grumpy all the time," she said with an impish smile. Seven years later she established the Patagonia Land Trust with money she made by selling her stocks in the global clothing franchise she helped create. The trust's brief is simple: Buy, restore, and conserve important habitat in Patagonia before it's too late.

Monte León had long been earmarked by the National Parks Association of Argentina to become the country's first coastal marine park. But the state didn't have enough money to buy it. So in 2000 the Patagonia Land Trust donated 1.7 million dollars to Fundación Vida Silvestre Argentina (the World Wildlife Fund of Argentina), which then purchased Monte León. Tompkins kept 300 acres and the ranch house, which is now run as a guesthouse. The remaining 155,000 acres, including one of the largest penguin colonies in southern Patagonia, is unofficially open as Monte León National Park.

For Javier Corcuera, the director of Fundación Vida Silvestre, last year's signing ceremony in Buenos Aires, when Monte León was formally donated to the nation, had special meaning. "I felt that afternoon that I was leaving something to my three children," he says. "And Kris Tompkins was the key in making that happen. No one in Argentina had come forward to support the project. I hope her effort will inspire people here to do the same thing."

Tompkins and the Benettons are not the only wealthy foreigners buying up Patagonia. In recent years the region's wide-open spaces and breathtaking scenery have made it a fashionable new frontier for the super-rich: Montana at bargain-basement prices. George Soros, Sylvester Stallone, Ted Turner, and Michael Douglas have all bought properties. Not surprisingly, in a part of the world that still remembers U.S. support of brutal military juntas in the 1960s and 1970s, this gringo invasion has made many people suspicious of Tompkins' intentions. In fact, most Argentines I spoke to about Tompkins had a hard time believing she's not buying up land to gain control of valuable natural resources such as water or minerals.

Tompkins is unfazed. "How to conserve these grasslands and balance that with the local economy is a dance," she said as we barreled down a dusty, stone-strewn track en route to Dor-Aike, a neighboring estancia the Patagonia Land Trust is also preserving. "In the Tehuelche language, *dor-aike* means 'golden place,'" she said, pulling up to the pastel-colored farm buildings. "It's about 82,500 acres and has 13 miles of the Santa Cruz River running through it."

Sheep farming in Patagonia has a complex legacy. On the one hand it's a story of pioneering heroism, but it also precipitated what can only be described as genocide. To make way for sheep at the end of the 19th century, European settlers wiped out the Tehuelche, Selk'nam, Yámana, and Kawéskar peoples, who had occupied the plains of Patagonia for more than 10,000 years. Foxes and pumas were poisoned with arsenic-coated meat. Then in the 20th century, farming practices that placed short-term profit above long-term care of the land caused the desertification that afflicts the region today.

"They trashed the land," said Tompkins curtly. It seemed an arrogant thing for an outsider to say about people who have lived here 150 years, but Javier Corcuera of Fundación Vida Silvestre agreed. "Unfortunately it's true. In Santa Cruz Province alone nearly 50 million

SPLENDOR ON HIGH

Whipped into lens-shaped swirls by winds that blast across the continental ice cap—the world's largest mass of ice outside the polar regions—lenticular clouds spread a sunset-bronzed canopy over Glaciers National Park. In Patagonia nature still outshines the human presence.





acres have been irrevocably damaged because of overstocking. Patagonia is like the Wild West a hundred years ago. Ranchers do what they want. But we have to understand the difficulty of living in Patagonia, and the history. Until recently environmental issues were not even in the language."

For Tompkins they're a passion. "I'm very aware that I am a guest here," she said as we drove down to the river. "The first thing we'll do is take down all the fences. There are tens, if not hundreds, of miles of fences that will come down."

Tompkins estimates that it could take a century for the land to recover, but the effects of the restoration program are already becoming apparent. The wild grasses are growing back; pumas are thriving. As we reached the river, a herd of guanacos came galloping across the steppe, their necks stretched forward into the wind.

"Hopefully the land we've donated will one day be patches of wildness," she said. "Little petri dishes, remnant forests or wetlands or grasslands from which the seeds of restoration can come."

Soon after leaving Tompkins, while driving along a plateau above the Santa Cruz River, I stopped to take in the view. I walked to the edge of the valley and sat down on the grass. Below, the land extended toward the horizon like a rumpled camel-hair coat. The grass waved and trembled in the wind, and as it did so, it changed color from chamois to silver back to chamois. The hillside looked alive and in motion, like water. There was an immense feeling of space, and of silence. Moments later a giant Andean condor sailed up the valley, its 12-foot wings beating against the wind.

"In calling up images of the past," Darwin wrote in the last chapter of *Voyage of the Beagle*, "I find that the plains of Patagonia frequently cross before my eyes; yet these plains are pronounced by all wretched and useless. They can be described only by negative characters; without habitations, without water, without trees, without mountains, they support merely a few dwarf plants. Why then . . . have these arid wastes taken so firm a hold on my memory?"

WEBSITE EXCLUSIVE

To see more of the "uttermost ends of the Earth," view a Web-only photo gallery of the best of the rest—with how-to tips—from photographer Peter Essick. Then plan a visit using our list of travel websites at nationalgeographic.com/magazine/0401.

It was a question I had puzzled over as well. On my journey through Patagonia I'd seen whales and penguins, sea lions and condors, majestic glaciers and snow-capped mountains. But now when I think of Patagonia, none of these come to mind. Instead I see the wild, wind-raked spaces of the steppe. And a woman called Doña Dominga Rosario Guajardo.

"I've lived here for 32 years," she told me as we sat by the stove in the kitchen of her remote hut in the Cordillera del Viento—"mountains of the wind"—in the far northwest of Argentine Patagonia. "When I first came here, there were only the two mud huts you can see outside. I renovated them with my bare hands and lived there until my son built this place for me."

Doña Dominga is what is known in Argentina as a *puestero* (or in her case, *puestera*)—ranch hand is the closest equivalent in English. She doesn't know exactly how old she is but said she was four or five in 1930, when her parents registered her birth. As a young woman she was engaged to be married, but as the bridegroom and her family waited in the church, Doña Dominga rode up into the hills. She never came back. "*Era un hombre guapo*—He was a great-looking guy," she said wryly, lifting a blackened kettle off the stove and pouring hot water into a red enamel mug filled with yerba maté, a bitter herb drunk like tea throughout the region.

Doña Dominga's face was a map of her world. Lined with fissures from a lifetime's exposure to Patagonia's fierce sun and wind, it looked like the cracked mud in a dried out riverbed. Her eyes were red and rheumy from the dust and



wind. A scar climbed like a briar from her upper lip to the edge of her nose. “I always worked like a man,” she said, sipping her maté. “I looked after the animals, collected firewood, fixed fences.”

Doña Dominga had almost no possessions. Along one wall was a table made from bits of four-by-four nailed together. On the other side of the room was a chipped and battered dresser with a few cups and plates, worn cooking pots, and simple kitchen utensils. A dust-caked transistor radio hung from a rusty nail. Yet she welcomed me with the graciousness of a duchess, and like almost everyone I met in Patagonia, she had an undaunted—as well as generous—spirit.

“I was born with *un paso corto*—a short step,” she said, referring to her humble origins. “And I’d like to die like that.” A wide grin revealed a row of pink, almost toothless, gums. “Though I’d like to have electricity.”

LASTING TREASURES

Reaching for the stars, araucaria trees soar to more than a hundred feet in Copahue Provincial Park. Living relics of the Jurassic period, these thousand-year-old giants stand as symbols of Patagonian tenacity in a landscape both severe and sublime.

As she spoke, a blast of wind sent a plastic bucket clattering across the patch of sunbaked dirt outside, where Doña Dominga kept a few scrawny chickens. Moments later the wind came swirling through the open door, lifting the sheets of faded newspaper covering the windows, rattling the cups, and making the stove gutter so that the kitchen was filled with woodsmoke. I closed my eyes. When I opened them, my hair, my clothes, the pages of my notebook were covered with specks of grit and dust. And Doña Dominga was laughing. □




STAR SEARCH

RECOVERED FROM
SMUGGLERS IN A
DARING POLICE STING,
A 3,600-YEAR-OLD DISK
REVEALS THAT BRONZE
AGE EUROPEANS WERE
SURPRISINGLY ACUTE
STUDENTS OF
THE NIGHT SKY.

BY HARALD MELLER
PHOTOGRAPHS BY
KENNETH GARRETT

Buried on the Mittelberg hill near the town of Nebra in 1600 B.C., the sky disk shines at sunset in central Germany. The disk, which tracks the sun's movement along the horizon, contains the oldest known depiction of the night sky and may have served as an agricultural and spiritual calendar.





**IF THE SKY DISK COULD PREDICT CELESTIAL
EVENTS, IT WOULD HAVE WIELDED ENORMOUS
POWER TO ITS OWNER—LIKE PHARAOHS WHO
COULD FORECAST THE NILE'S ANNUAL FLOODS.**

PAGAN REDUX

On May Day Eve, a masked devil dances on a hill near the Harz mountain village of Thale during Walpurgisnacht. The revelry evolved from pagan spring festivals celebrated in the Middle Ages, but a 3,600-year-old mace found here links the hill to religious ceremonies during the Bronze Age.

In the basement café of a tourist hotel in Basel, Switzerland, I tell the smuggler and his accomplice that the exquisite bronze sword he has placed on our table is a worthless forgery.

Having handled hundreds of Bronze Age artifacts, I know this sword actually dates to 1600 B.C. But I'm bluffing, for if the smugglers learn its true origin, they'll never part with the real prize: a bronze disk from the same period that is purported to be the earliest known depiction of the cosmos. If authentic, the disk would be one of the most important finds of the early 21st century, and its value would far surpass that of the sword.

Despite my bravado, I'm extremely nervous. As an archaeologist, such cloak-and-dagger deals are new to me, and I can't forget the advice from the Swiss police officer who had set up this sting: "The most important thing," he'd said, "is that you survive. We lose people in some of these transactions."

A week earlier the smuggler's accomplice had phoned to arrange our meeting, assuring me they would bring the disk. Now I'm getting impatient and demand to see it. The smuggler

slowly pulls an object wrapped in a towel from beneath his shirt. As he opens the package, I stifle a gasp. Indeed it's a bronze disk, and it's the size of a large dinner plate. It's been crudely cleaned, and I can make out a gold sun and moon set in a field of glimmering gold stars. One constellation appears to be the Pleiades. If the disk is the same age as the sword, it will precede the beginning of Greek astronomy by a thousand years. And it will far surpass monolithic Stonehenge. At this moment, with my heart racing, I know how Howard Carter must have felt when he first glimpsed King Tut's tomb.

After I closely examine the piece, we agree on a price. I'll pay \$400,000 for the disk and other items found with it—two swords (including the bronze one I had already seen), two axes, two spiral armbands, and a chisel—all forged from bronze. Then I politely excuse myself to the men's room, snap open my cell phone, and alert the police. After what feels like an eternity, six officers swarm into the café and arrest us all. The smugglers were shocked because I'd assured them that Switzerland's neutral status would afford a safe haven for our meeting.



THE SMUGGLER PULLS AN OBJECT FROM BENEATH HIS SHIRT. I STIFLE A GASP: IT'S A BRONZE DISK WITH A GOLD SUN AND MOON.



LUCKY FIND

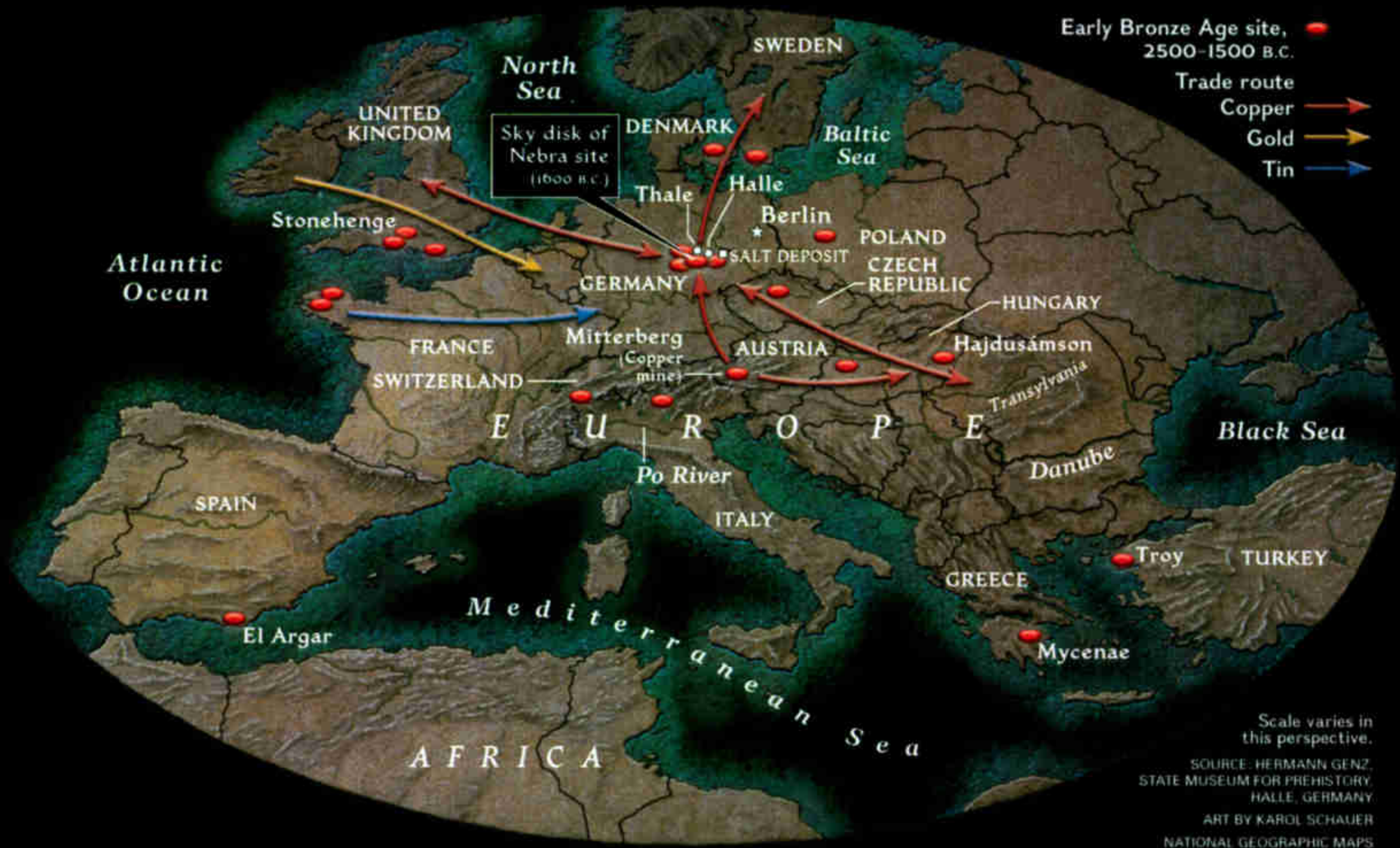
The Mittelberg hill (left, at upper left) rises above the farming village of Wangen in the Unstrut valley, which humans have inhabited for at least 440,000 years. Looting wasn't a problem when the Mittelberg hill fell under the jurisdiction of the East German police state. But after the fall of the Berlin Wall, West German entrepreneurs armed with metal detectors began scouring the landscape for artifacts. Collectors employed out-of-work locals, providing detectors and promising to buy anything they found. This was the fate of the sky disk of Nebra—stolen from a site known for its archaeological significance (clearing, above). Most artifacts vanish in the black market, but police and forensic



scientists managed to recover the sky disk and later pinpoint the spot where it had been buried. Kneeling beside the mound where looters unearthed the sky disk cache, I discuss our excavation with colleagues from the State Museum for

Prehistory in Halle. A raised ledge, three feet high and 75 yards in diameter, surrounds the site. Two additional berms bracket the clearing—perhaps a warning to ancient wanderers that they were treading on holy ground.





EARLY SUPERHIGHWAYS

Central Germany was an economic hub of Europe (above): There were deposits of salt and copper, and traders brought tin and gold. Today prospectors pan local streams for gold (below), but metallurgists confirmed that the gold on the sky disk and other items in the cache was not from the region. The cache contained tools (right) and swords inlaid with gold trim (left), decorative details previously seen only on artifacts from the great Mediterranean cultures of the period.



3,600 YEARS AGO THE SITE WAS LIKELY LOGGED BARE, AND A CIRCULAR BERM MAY HAVE ENCLOSED AN EARLY OBSERVATORY.

So ended one of the most bizarre yet exhilarating periods of my career. It had begun in May 2001, shortly after I was appointed director of the State Museum for Prehistory in Halle in the state of Saxony-Anhalt, an antiquities-rich but economically depressed region of former East Germany plundered by looters since reunification in 1990.

A colleague at the Museum of Prehistory and Early History in Berlin told me he'd photographed the disk in 1999 when a pair of black marketeers offered to sell it for a half million dollars. He wanted the disk for his museum's collection, but when he heard it had been found in Saxony-Anhalt—and by German law therefore belonged to that state—he told the men their find was illegal.

Archaeologists hadn't seen the sky disk since. It changed hands several times on the black market until it finally resurfaced in January 2002. That's when its newest owners persuaded *Focus*, a German news magazine, to run a piece on the disk, expecting to start a media frenzy that would increase its value. I learned of the story and tipped off the police, who devised the sting: I'd play the Indiana Jones role, pretending to represent a large bank buying the disk for my museum.

After the arrests in Basel (I was released immediately, of course, my arrest being a show for the sting), police found the remaining items at the home of one of the smugglers. The style of the swords confirmed that they were roughly 3,600 years old. That meant the disk—looted from the same site—was of similar age.

Police later traced the disk to one of its previous owners, who agreed to cooperate with the investigation. He took me to the looted site on the Mittelberg, a large hill near the town of Nebra in Saxony-Anhalt. After a quick survey of the area, I found that the original looters had removed the artifacts from a stone mound buried near the top of the hill. A low circular berm nearly 75 yards in diameter surrounded the site. Known as ringed-ditch enclosures, such

structures are found throughout Europe and may have marked prehistoric ceremonial or holy places. Today the Mittelberg hill is heavily forested. But back in the Bronze Age the hill would likely have been logged bare (people relied heavily on timber for heating, cooking, building, and smelting), and the ringed-ditch may have enclosed an early observatory.

Wolfhard Schlosser, an astronomer at Ruhr University, examined the sky disk of Nebra and developed a theory on how it may have been used. He suggests that the ends of the two gold bands (one of which was lost in antiquity) along its outer edges mark the points on the horizon where the sun rises and sets on the summer and winter solstices—the longest and shortest days of the year. An astronomer could have followed the sun's path along the gold bands to establish a rudimentary calendar, providing farmers with information critical for planting and harvesting.

The circular group of seven gold stars on the sky disk is almost certainly a representation of the Pleiades constellation. In early March its disappearance in central Germany signals the beginning of the planting season.

Schlosser is less sure of the significance of two other objects on the disk. One is shaped like a crescent moon; the other is round, what I first thought to be the sun but now think is the darkened moon of a lunar eclipse. We know that once every decade the Pleiades appears next to the crescent moon, as seems to be depicted on the disk. A lunar eclipse follows seven days later. If Bronze Age astronomers used the disk to predict eclipses, it shows that these so-called barbarians had been studying the heavens for generations.

The sky disk had religious significance too. Overlaid on it is a curved gold object laced with feather-like oars, set between the horizon bands. It may represent the night ship, a celestial craft early peoples believed carried the sun god on his journey from darkness to dawn. The night ship motif was common in Egypt, but its appearance



ART BY KAROL SCHAUER



MOUNTAIN TIME

The Mittelberg hill circa 1600 B.C. (above) had a clear view of distant landmarks. From here, on summer solstice, the sun descends on the Brocken, at top right, the highest peak in the Harz range. Orient the northern end of the disk's western band with the Brocken, and the opposite end of the band aligns with sunset on winter solstice. Frosts typically end in the region after May 1—when the sun falls behind another prominent hill called the Kyffhäuser. When a gold band fell off the sky disk, a priest may have buried the disk in the cache (left), believing the damage diluted its spiritual powers.



on the sky disk is the earliest evidence that Bronze Age Europeans had adopted this religious icon. It would later become as important to Bronze Age cultures as the crucifix to Catholicism.

Bronze Age people traveled along extensive trade routes. From the Baltic to the Mediterranean, these routes converged on what is now central Germany, source of several rare and sought-after minerals, including salt and copper, which was combined with tin to make bronze.

The abundance of these natural resources may have given rise to a wealthy and powerful individual who commissioned the sky disk—someone, perhaps, like the man buried in 1942 B.C. near Leubingen, a small town 20 miles southeast of the Mittelberg hill. With numerous weapons and gold trinkets, his is a remarkably opulent grave for the period. What made this man rise above the rest of society? Did he control a valuable salt spring? Whatever his trade, he may have decided to spend his newfound wealth on a device for predicting celestial events. Anyone with such knowledge would have wielded enormous influence—just as pharaohs rose to power in part because they could forecast the Nile's annual floods.

Since that day in Basel when the sky disk was recovered, it has continued to fire the imaginations of archaeologists, astronomers, and visitors to the museum in Halle. A few of the disk's more fanciful admirers believe it might be a time-travel device. In a way they're right.

Bronze Age people left behind no written texts and only a few rock drawings. The sky disk of Nebra transports us back, shining light into an impenetrable period of human history. We can only wonder what other antiquities lie out of reach—perhaps still buried or in the hands of looters—that will one day bring us even closer to the mysterious inhabitants of Bronze Age Europe.

CLUES FROM AN ANCIENT ARTISAN

After scouring away thousands of years of grime and corrosion, museum researchers ran numerous tests on the disk to determine how it was constructed and what raw materials were used.

Chemist Heinrich Wunderlich (below) with the State Museum for Prehistory believes the gold in the disk may have come from Transylvania. Chemical analysis of the copper in the disk, swords, and tools by metallurgist Ernst Pernicka of the Institute of Archaeometry in



WEBSITE EXCLUSIVE

Kenneth Garrett required a police escort when he photographed the sky disk. Find his story and a gallery of unpublished images at nationalgeographic.com/magazine/0401.



Freiberg, Germany, showed that the metal was derived from a single source, most likely located in the Austrian Alps.

The sky disk went through several incarnations. The stars, crescent moon, and round object—perhaps the sun, full moon, or darkened moon of a lunar eclipse—were added first.

Astronomers believe that one particular cluster of seven stars is the Pleiades. The constellation was important to many early cultures for navigation and to track changing seasons.

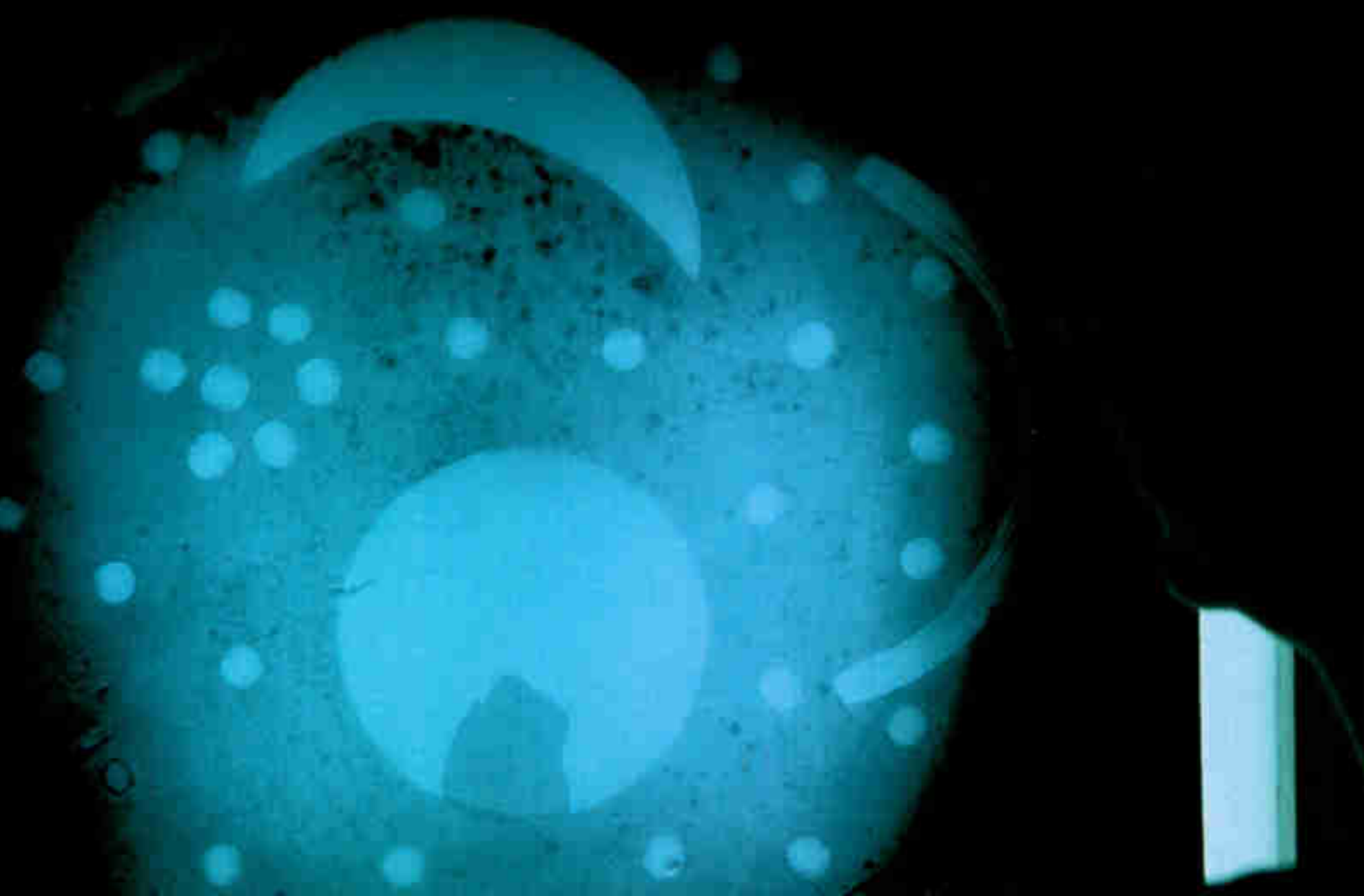
An x-ray image of the disk (right) reveals that the horizon bands obscure two indentations where stars were once affixed. This means that the horizon bands were added during

a second stage, possibly by the same artisan who crafted the original disk. At this point the disk may have been used as a device for tracking the sun's movement through the sky.

At a third stage, a craftsman incorporated the incised gold night ship, an ancient symbol (below, at right). And a final modification was made when a

series of holes along the perimeter were punched through the gold bands and the disk (above, at right), perhaps to fasten the sky disk to fabric.

No doubt further study will turn up more clues. But with nothing comparable in the archaeological record, the complete story of the sky disk of Nebra will likely remain a mystery. □



In the dim light of a household chapel, a monk from the local Buddhist monastery chants prayers to bless a family's crop during the brief Himalayan growing season. In this remote valley isolated by past war, photographer Mattias Klum discovers a redoubt of peace.

In. their OWN world

THE SACRED COMMUNITY OF INDIA'S FORBIDDEN HANLE VALLEY



It's after dark when photographer Mattias Klum approaches the last army checkpoint on the road to Hanle, a little-known settlement in India's northern Himalayan region of Ladakh. From Leh, the capital of Ladakh, it has taken Mattias 12 hours by four-wheel drive to get here. Preparation for his visit took much longer: Permission to visit Hanle and its *gompa*—a 17th-century monastery on the ancient trade route that once linked the kingdoms of Ladakh and Tibet—was more than two years in coming. Now he shows the guard his permit from the Indian government and a letter from the Dalai Lama himself. But Mattias's request to pass is met with disbelief. Examining the documents, the guard informs him, "This is not true."

The guard's reluctance to let the foreigner continue on is understandable. Other than a handful of scientists bound for the government-run observatory in Hanle, most Westerners have been denied access since the end of the Chinese-Indian war of 1962. Fearing that spies from China might slip over the border into Hanle, which sits just 12 miles from the disputed frontier, the Indian government declared the area off-limits. But after a careful review of Mattias's documents, the guard at last allows him to pass.

Enforced isolation has slowed the pace of change in the Hanle Valley, which is home to roughly a thousand people—about 300 of whom reside in the village of Hanle. When Mattias arrives at the monastery, the monks are cautious at first, unsure of what a photographer does. But the Dalai Lama's letter, which they place on a throne reserved for a visit from His Holiness, reassures them, and they become more at ease. The monks talk with Mattias and slowly begin to understand why he wants to take their pictures. They wonder what kinds of attention and perhaps help his work might bring the *gompa*, a crumbling stone edifice where 10 monks live and another 33 come regularly for prayers.

Gradually these sons of local herders allow

Mattias to photograph life at the monastery, which is steeped in the Buddhist ideals of humility, patience, cooperation, and compassion—values that are also embraced at a nunnery across the valley. Indeed, Hanle's high-altitude desert requires everyone to keep a tight reign on selfishness and pride. Survival in the harsh climate means family members must put aside individual interests to work together and overcome personal conflicts as they endure long winters in close quarters.

Of all the monks, Mattias is drawn to Lama Zotpa, who is greatly respected by his fellows. The holy man's presence forces Mattias to reexamine his own life. "He looks at you with kindness, and then he looks right through you and into your soul," Mattias says. "At times I felt very small, even superficial." Often during his five weeks in Hanle, Mattias was moved by the profound tranquillity of the community: "There was a stillness about it. I felt as if I was visiting

the only truly peaceful place on Earth."

Will the peace that Mattias experienced endure? Modern influences are slowly reshaping Hanle. Children once sent to tend livestock in the mountains enroll in government schools. Some eventually leave to attend university or look for jobs. Stone houses are replacing yak-hair tents, parkas are worn over

wool robes, and shops stock manufactured goods trucked in from Leh. When the Dalai Lama visited the valley last year, he was whisked away to his next destination by helicopter.

Hanle's monks are adjusting to this transformation. As Buddhists they expect and accept change in a world they see as transitory. Writes Tibetan lama and author Sogyal Rinpoche: "The realization of impermanence is paradoxically the only thing we can hold on to, perhaps our only lasting possession."



WEBSITE EXCLUSIVE

Hear the chanted prayers that echo through Hanle's monastery and see more images by Mattias Klum at nationalgeographic.com/magazine/0401.

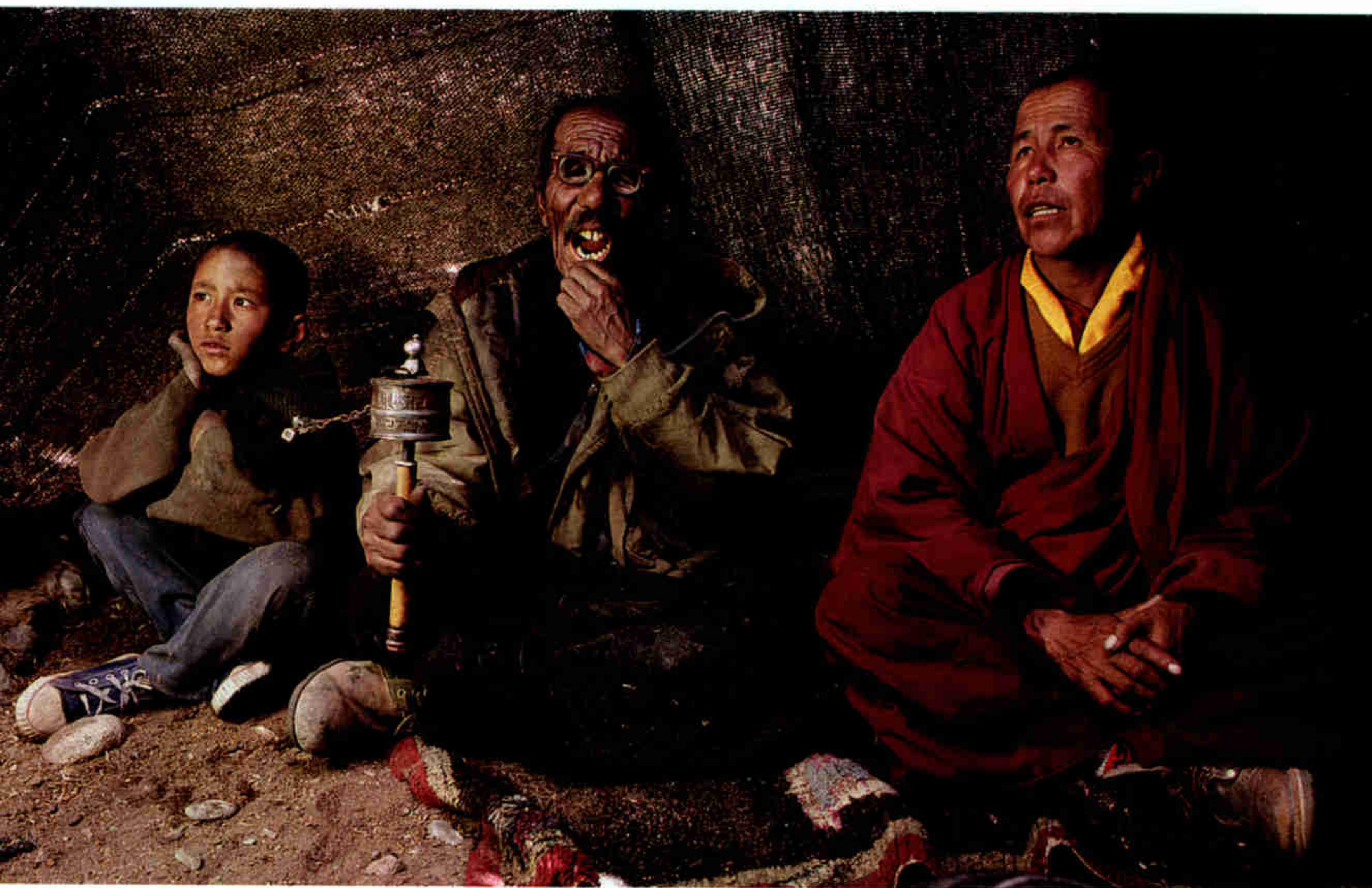
An aerial photograph of a high-altitude mountain valley. The terrain is rugged and rocky, with deep shadows and bright highlights. In the foreground, a large, multi-story stone building complex, the Hanle monastery, is situated on a small plateau. The building has a prominent central tower and several smaller structures. The surrounding landscape is a vast, open valley with scattered rocks and sparse vegetation. The overall scene is one of a remote, high-altitude location.

Dwarfed by 20,000-foot peaks, Hanle monastery has sustained Tibetan Buddhism for four centuries in this far corner of India. A government ban on travel near the Chinese border keeps outsiders away.



FROM HERDERS TO HOLY MEN

Monks ride to a retreat cave (left), where they'll meditate alone for days, even months. Buddhists believe that each monk's spiritual progress helps the wider community. The monks' prayers and rituals bring protection and prosperity, and sending sons to become monks earns parents a happier rebirth. When boys arrive at Hanle monastery, they assist with chores, such as laundry (lower left) and learn to read and write. But the life of renunciation is not for everyone: When Lama Zotpa (below, at right) was 18, his brother fled the monastery to open a restaurant in Leh, the region's capital. Lama Zotpa took his brother's place. Years later Lama Zotpa visits his sick father, middle, who, left without his sons, lives in the care of a young relative, at left. Spinning a prayer wheel, the father greeted Lama Zotpa, embracing him as a son and a holy man.





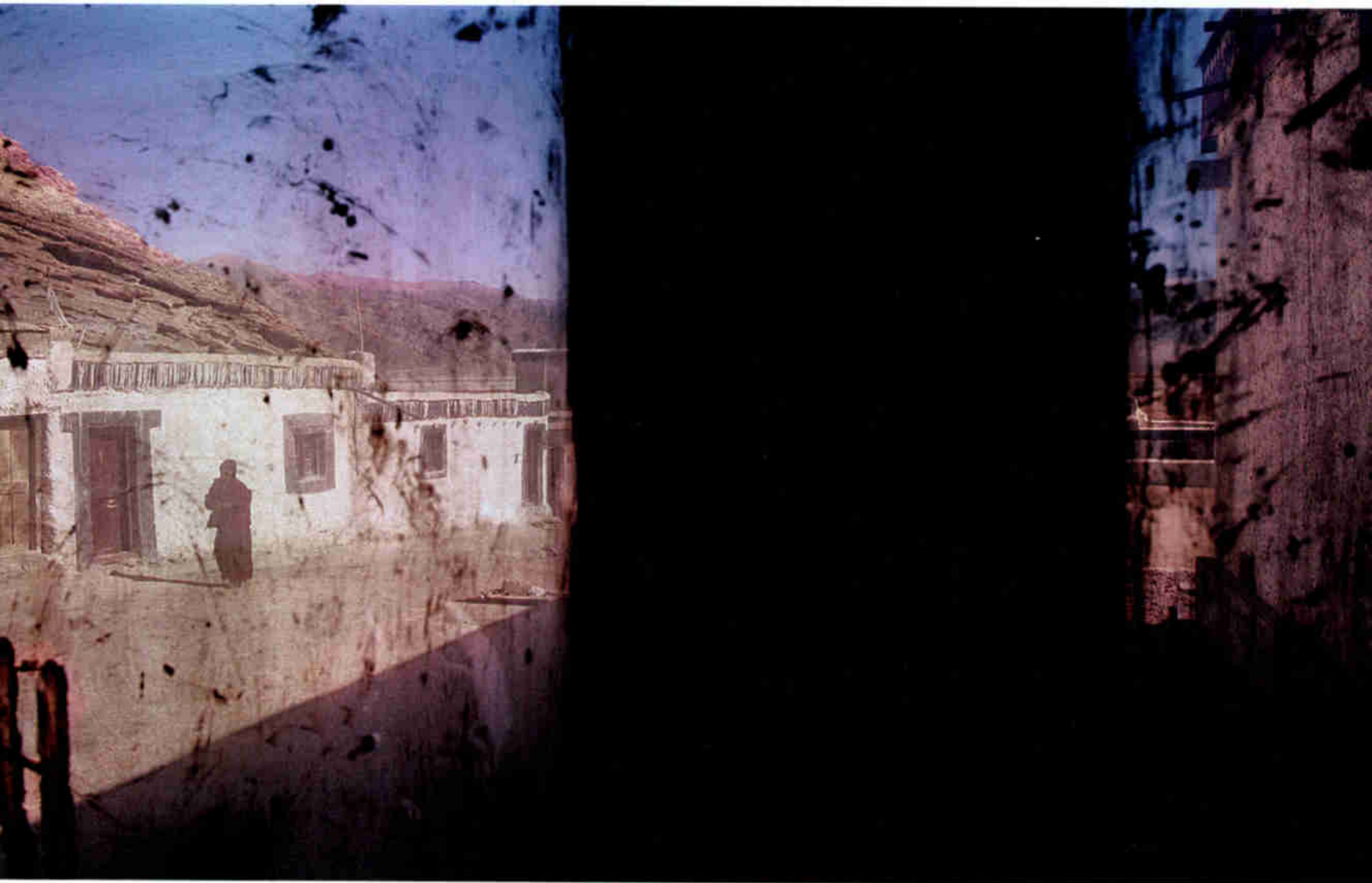


In the valley below the monastery, a monk helps prepare a villager's field for barley. Local people make food offerings to the monastery and give monks milk, sugar, and salt for performing rituals and prayers. But some of the monks' food must come from their families.

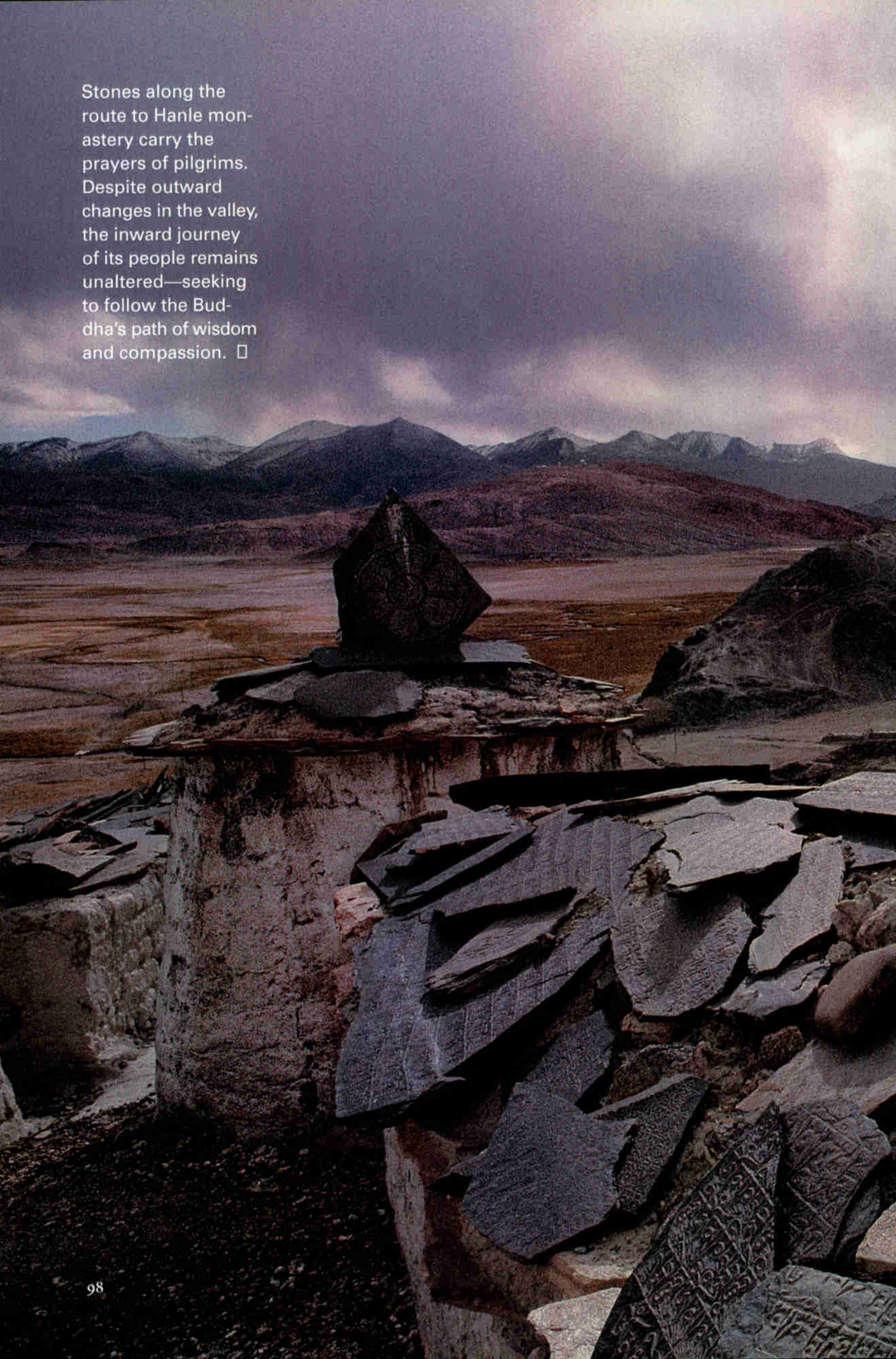


QUIETING THE SELF


The view of a courtyard through a grime-spattered window (below) is all a nun might see for weeks as she meditates in the solitude of her cell at the nunnery near Hanle monastery. Donations from outside the valley established Tashi Choeling (Auspicious Dharma Center) in 1983, providing enough support to its 47 resident nuns so that they don't have to farm or herd most days. Bundled against springtime cold, two nuns gather dried dung for fires (left). While secluded indoors (lower left), a nun performs a meditation given to her by a visiting *rinpoche*, or senior teacher: She pours seeds onto a plate, gently brushes them off, then repeats the process for hours. "You have to go through the boredom of repetition until an energy arises of itself," says a Ladakhi yogi. "[Then] you will find yourself entirely free of wanting anything."



Stones along the route to Hanle monastery carry the prayers of pilgrims. Despite outward changes in the valley, the inward journey of its people remains unaltered—seeking to follow the Buddha's path of wisdom and compassion. □

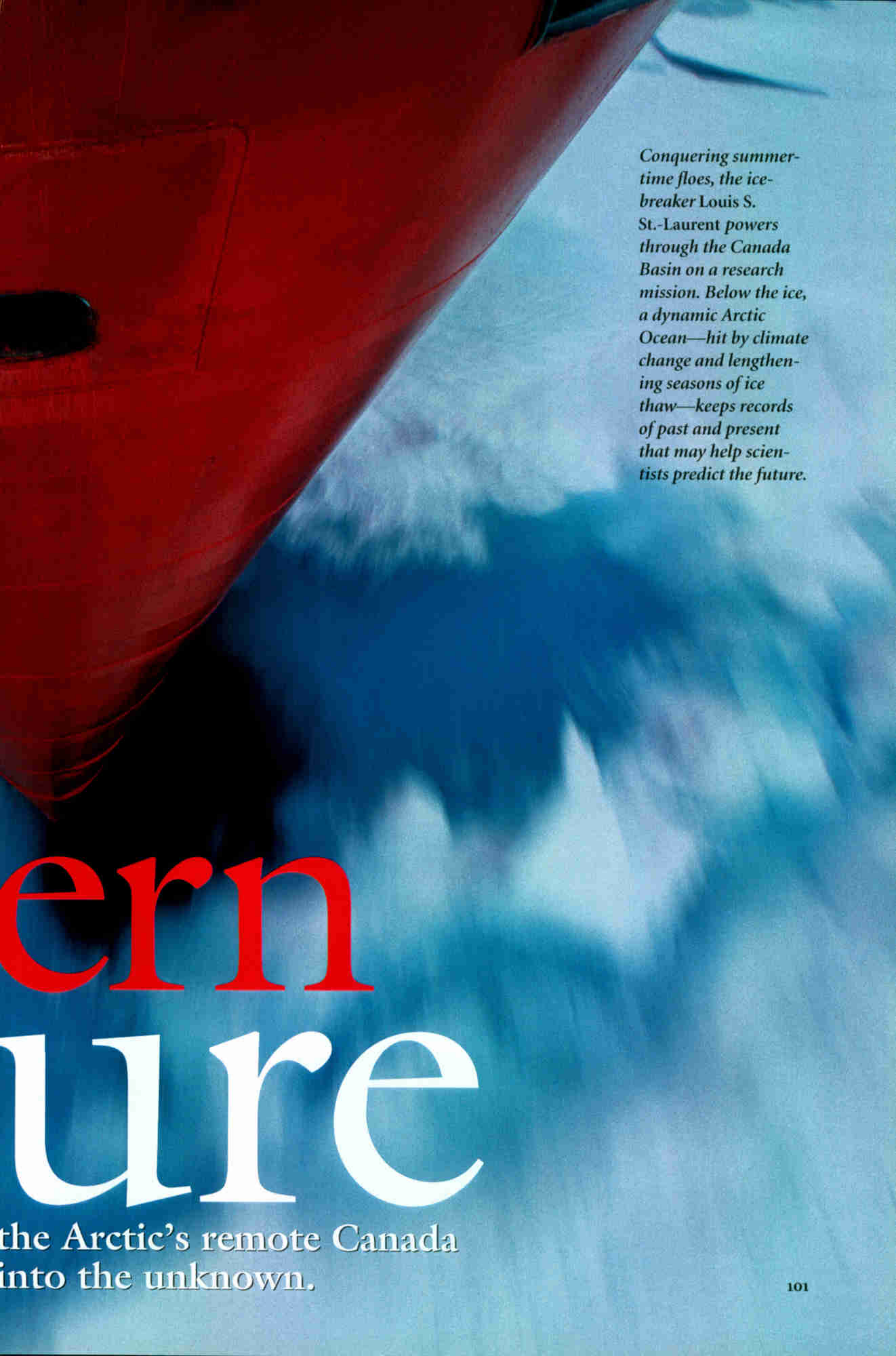






North Expos

Scientists exploring
Basin take a cold dip

A close-up, low-angle shot of the red hull of an icebreaker ship, likely the St. Laurent, as it moves through a field of blue-tinged ice floes. The ship's hull is on the left, curving towards the center, and the ice floes are on the right, creating a sense of motion and depth. The lighting is dramatic, with the red of the ship contrasting sharply with the cool blues of the ice.

Conquering summer-time floes, the icebreaker Louis S. St.-Laurent powers through the Canada Basin on a research mission. Below the ice, a dynamic Arctic Ocean—hit by climate change and lengthening seasons of ice thaw—keeps records of past and present that may help scientists predict the future.

ern ure

the Arctic's remote Canada
into the unknown.





Cold, blue gloom greets a diver as he scans the base of a multiyear ice floe some eight feet thick—laced with channels housing myriad life-forms. A safety line manned from above helps him stay oriented in strong currents between the shifting ice masses and abyssal depths.

By Jennifer Steinberg Holland

NATIONAL GEOGRAPHIC WRITER

Photographs by Paul Nicklen

Rolf Gradinger is getting antsy. Braced against the ship's cold rail, his orange flotation suit over worn sweater and high-water pants, he runs a hand through his slightly wild beard. The knit hat's off again, and strands of salt-and-pepper hair poke skyward as he scans giant rafts of multiyear ice on the Arctic Ocean. So close—yet still out of reach.

Five days into an exploratory research cruise aboard the Canadian Coast Guard's icebreaker *Louis S. St.-Laurent*, the German ice expert, who teaches marine ecology at the University of Alaska Fairbanks, has yet to lay a boot on the frozen sea. Down below, the ship's hull groans as it battles the white sheet—the thickest so far, maybe eight feet—grinding, clanging, and squealing as steel meets ice. Rolf leans over the rail to watch the pointed bow come down like a sword on the massive slab, sending cracks racing ahead like frightened snakes and ice cubes the size of VW Beetles rolling over along the hull. And he waits for the captain to announce that ice research can commence. And waits.

That's the way it's been for Rolf and 43 other scientists on a 24-day, 2,400-nautical-mile voyage—jointly funded by the Ocean Exploration Program of the National Oceanic and Atmospheric Administration (NOAA), Japan Marine Science and Technology Center, and Fisheries and Oceans

Canada. Their collective mission: to explore the Canada Basin, a 2.3-mile-deep bowl in the Arctic Ocean. Remote, achingly cold, and ice-covered for much of the year, this part of the ocean appeals mainly to whales, seals, and polar bears. Only humans bent on exploration, and with the right ship to get here, have reason to visit. And once they arrive, nothing comes easily.

"Plan for logistical nightmares," chief scientist Fiona McLaughlin of Canada's Institute of Ocean Sciences (IOS) had warned on day one.





Her words were quickly borne out. Less than 24 hours after leaving the wee Canadian town of Kugluktuk, the *Louis* suddenly turned around and headed back. It had been called on for a search-and-rescue mission. Two Inuit fishermen and a boy were reported missing. The ship's helicopter crew eventually spotted the trio camping on an island, and all was well. But for the scientists, a full day of travel was lost.

Back on course toward the Beaufort Sea, the teams are eager to get to work at 25 scientific

Researchers clad in survival suits hitch a ride to a snow-custed sheet of sea ice strung with blue melt ponds. Measuring light, salinity, nutrients, and biomass in the ice and meltwater will give them a baseline from which to assess change.

stations en route. But each stop deals them another kind of waiting game: for the fog to lift, for the wind to stop, for one study to wrap up so another can begin. Demand is high for deck space and hands, while moody weather and equipment

The ice keeps moving, so we do too.

—Fiona McLaughlin, Oceanographer and Chief Scientist

failures add to the strain. Everyone knows there's too much work for the allotted time. The oceanographers want to extract heaps of data about ocean chemistry and circulation from the basin's stratified water column, in part to better understand its links to the global ocean. The biologists want to sample life from the ice to the sea bottom. The basin's deepest waters have lain quiet and isolated for more than 500 years—the oldest

Rolf Gradinger is here to examine life in the ice. But first he has to get off the ship. Until now, ice has made appearances, but quickly moved on. Its scarcity in the southern Beaufort Sea isn't a big surprise in August (the winter-long freeze-up starts in September) but is still a major frustration both for him and for the Japanese team, who will need a sprawling slab of multi-year ice ten feet thick in which to embed a buoy

strung with ocean-monitoring instruments. "That's just how it is up here," Fiona says after the ship steams all night using ever changing satellite images to chase floes. "The ice keeps moving, so we do too." Also, summertime floes can be brittle platforms, and Captain Martin Marsden isn't taking risks. The ice is too thin here, too unstable there. As his research stalls, Rolf's sweet smile wanes. Opportunities to come all this way are far between and extremely pricey, demanding monumental feats of organization. Plus, there's a bigger problem. Beyond the typical seasonal melt, the sea ice out here seems to be disappearing.

There's no consensus on the extent of the melt. Data from submarines suggest that Arctic sea ice has thinned by 40 percent in the past 30 years. Scientists who disagree

argue that much of the thickest ice had been piled up by winds far from the subs' tracks. Some estimate up to 15 percent thinning, a 3 percent loss of area per decade, and cite natural cycles as at least part of the cause. But few specialists deny that the overall ice trend is downward. And the effect quickly snowballs. As more water is exposed, the upper ocean absorbs more sunshine, speeding up the decline.

That's bad news for the animals and people who rely on ice for home and hunting grounds. It's better news for those poised to profit from summertime shipping routes between Europe



Lowered into the sea, the unwieldy CTD/Rosette (above) records conductivity, temperature, and depth, and grabs water samples too. Oceanographer David Allen (right) injects a syringe of nutrient solution into a sample to see what grows. One focus: microbes that feed on pollutants.

in the Arctic—and nobody really knows what they contain. They could house an "isolated Eden," suggests Kathleen Crane, a NOAA oceanographer and the U.S. mission coordinator. Relict species may lurk down deep and in the pudding-like mud.





and Asia, new fisheries, and oil fields on continental shelves—though major economic, ecological, and sovereignty issues may muddle the benefits. Meanwhile, scientists are grappling with the complex phenomena linked to ice melt, including global warming and a high pressure system over the Arctic—one phase of the Arctic Oscillation (see map pages 110-11). That system could shift, turning today's balmy European winters into nasty cold ones, affecting agriculture, energy use, and tourism. Whatever happens, says Rolf, "there's no doubt the ice is changing, which means my work can't wait."

Finally, the *Louis* grinds to a halt, its nose plunged into the floe, and Rolf and his team zip on survival suits and cram wool-clad feet into thermal boots. They crowd into a steel basket, get lowered by crane, and are set free on the ice. Nine thousand feet of dark ocean lies beneath them, but there's some comfort in the giant red ship nearby and in the rifle-slung Inuit hunters,

John Alikamik and Joseph Illasiak, scanning the horizon for polar bears.

A team of divers has come too. Sleek black seals in their dry suits, they make their way to the ice edge and slide in, weighed down with video gear and sampling equipment. While Rolf works from atop the ice, they'll be sampling and documenting its complex underside.

Rolf trudges away from the ship to take ice samples. He wrestles the corer into place, bores down, kneels to coax out the Popsicle-like sample from the tube, and moves to the next spot. Later in the ship's shared lab he'll slice up, melt down, and test the samples for microorganisms. His wife, ecologist Bodil Bluhm, vacuums up samples from a blue melt pond (an ice-top pool). Others take salinity, light, and nutrient readings, crouched like orange-suited spacemen probing a pocked, white planet.

Revived by the bustle of work, Rolf is chatty. "There's nothing quite as surprising as animals

The ice cores we take out here are full of life. —Rolf Gradinger, Marine Ecologist



In a surprising discovery, divers find five-inch Arctic cod exploiting an unexpected habitat. Melted-out hollows within the ice seem to provide the fish refuge from predators—one of many ways life here has adapted to a frozen world. A simple suction device allows diver Jeremy Stewart (left) to snare the floe’s tinier tenants, pebble-size invertebrates called amphipods, as they skitter within reach.

specialized to live in ice, in six months of darkness,” he says. “Think of putting a plant in the freezer with the door shut for half a year—it’s sort of like that. But somehow life has

found a way to stay healthy despite the conditions. The ice cores we take out here are full of life. It’s still incredible to me.”

After five hours on the ice, the researchers pack it in. They’ve got what they need—at least at this station. Dodging melt ponds, they drag sledfuls of gear to the base of the ship and load the basket for the ride back up. Once fully thawed aboard the *Louis*, Rolf will get his first look at the ice’s underside via the divers’ videos. “Look! See that?” He points at an amphipod, a common, knuckle-size crustacean. “This perspective tells me so much about how these animals use their environment.” And then, finally, a surprise. Caught on film are Arctic cod—a key species in this ocean’s food chain—tucked away from predators’ jaws in under-ice crevices. “It’s a microhabitat we’ve never documented for these fish,” Rolf says excitedly. He rewinds the tape and watches it again. “There!

There!” His grin widens each time the hiding fish come into view.

As Rolf proceeds with his work, others wait anxiously on board ship to begin theirs. Marine ecologist Russ Hopcroft stands with arms crossed and gaze fixed on *Global Explorer*, the sunshine yellow remotely operated vehicle (ROV) parked on the forward deck. The brand-new device can dive to 9,800 feet and zip around for hours, piping back video so the scientists topside can *oooh* and *ahhh* as life-forms zoom into view. “The ROV is key,” says Russ, who like Rolf teaches marine science at the University of Alaska (where he’s the type of professor to yell “Holy copepod!” if the moment lends itself). “It gives us a first look-see, allowing us to answer the question, Who’s there? Any new species? Any species at all?” The robot also has a vacuum wand for gathering live samples intact—vital for identifying species. This will be the first ROV dip in the basin, and a lot is riding on its success.

Problem is, besides two shallow test dives, *Global Explorer* hasn’t gotten wet yet. High winds one day, around 30 knots, mean no deployment—the ROV’s insurance cuts out at 15. Later, a mechanical failure takes hours to repair. “After



PACIFIC OCEAN

Warm Phase temperature:
5-9°F (3-5°C) higher than normal

Lena
Siberia

Bering Sea

East Siberian Sea

Laptev Sea

ALASKA (U.S.)

Bering Strait

Chukchi Sea

Beaufort Gyre

Barrow

Canada Basin

Beaufort Sea

ARCTIC OCEAN

Lomonosov Ridge

Gakkel Ridge

North Pole

North Magnetic Pole

Mackenzie

Kugluktuk

Baffin Bay

GREENLAND

CANADA

Hudson Bay

ATLANTIC OCEAN

CURRENTS ROLL

Major movements of ice, surface water, and near-surface water are driven by the clockwise Beaufort Gyre. Below, a counterclockwise current carries waters of primarily Atlantic origins east along the continental margin. Meanwhile, deep waters of the Canada Basin are relatively static, isolated from the movement and mixing going on above.

ICE MOVES

Open water doesn't always mean ice has melted—winds and currents also move pack ice long distances. In fact, the amount of ice pushed out of the Arctic (via the Fram Strait, between Greenland and Spitsbergen) has in some recent years been twice the annual average of 10 percent.

Air current

- █ cold
- █ warm

Water current

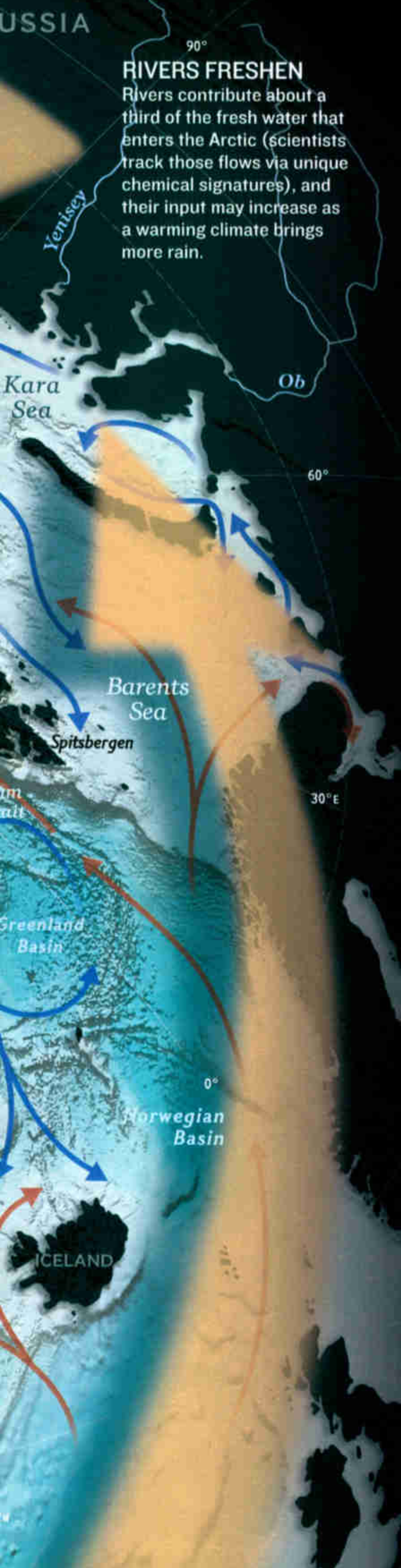
- ← cold
- ← warm

Scales vary in these perspectives. Distance from the North Pole to Barrow, Alaska, is 1,289 miles (2,074 kilometers).

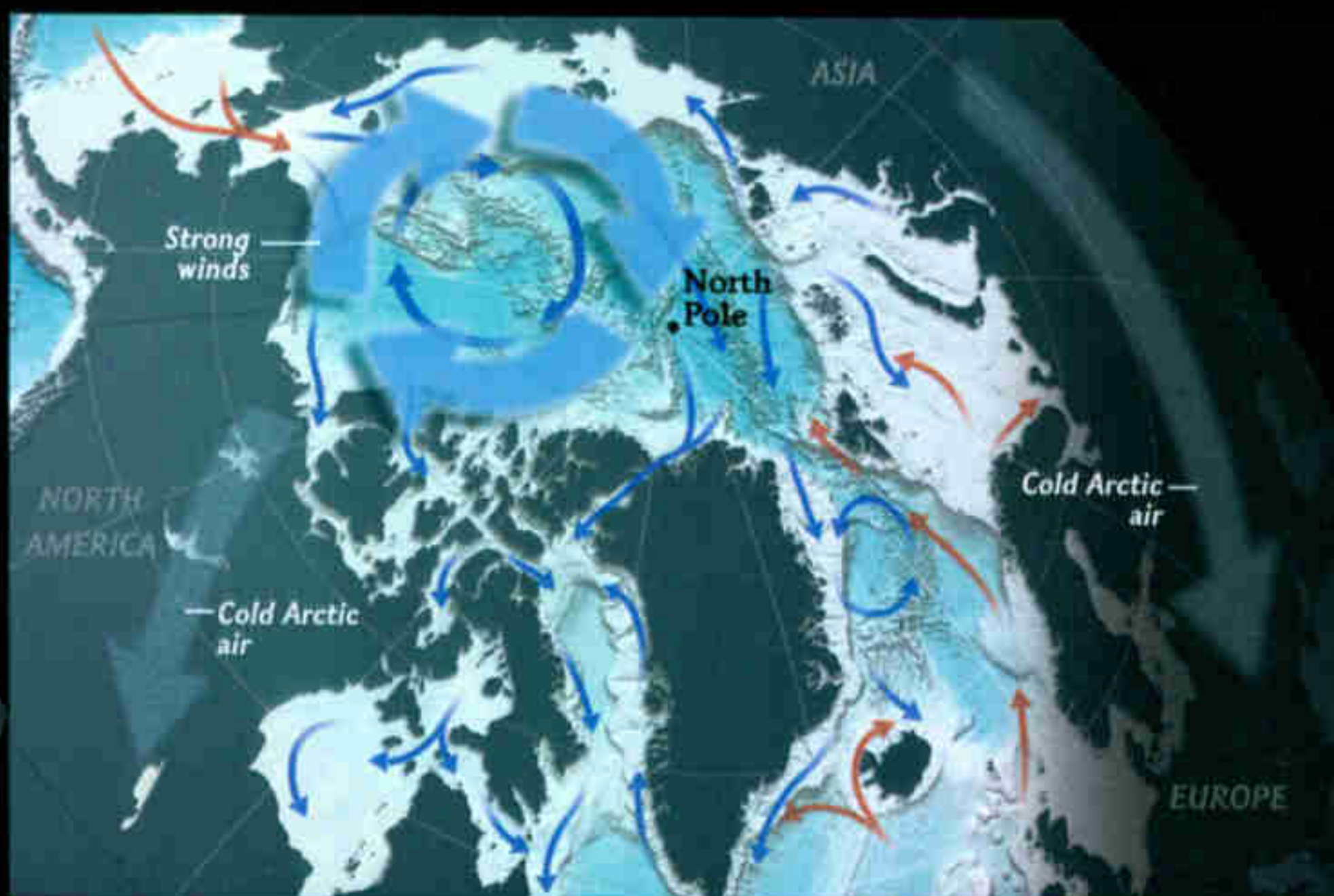
SOURCES: NOAA; NATIONAL ICE CENTER/NAVAL ICE CENTER; DAVID THOMPSON, COLORADO STATE UNIV.; JAMES MORISON, IGNATIUS RIGOR, AND MICHAEL WALLACE, UNIV. OF WASHINGTON
NATIONAL GEOGRAPHIC MAPS

Arctic Forecast

Partly to mostly slushy



The sea ice up north is melting. But why? Scientists point to the Arctic Oscillation, a weather pattern where high and low atmospheric pressure swings between the Arctic and lower latitudes. In recent decades that oscillation seems to be favoring its “warm” phase (left), possibly because of global warming, with climatic and economic impacts being whisked around the globe. Those impacts are most visible in the Arctic, so researchers come here first to find out what’s going on—and to predict what a change in the weather might mean for all of us down the line.

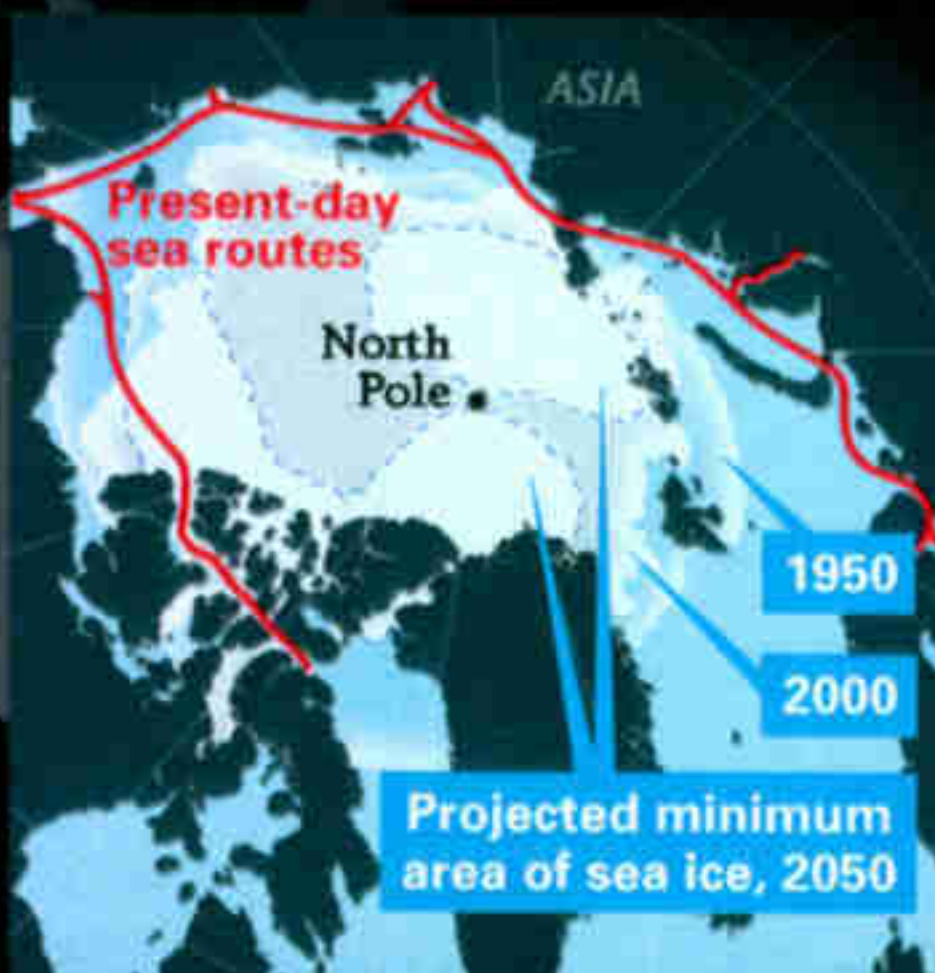


◀ WARM PHASE 1990s

Low pressure over the Arctic and strong eastward winds at high latitudes hold cold air in the north, keeping winters at midlatitudes mild. When winds push ice out of the Arctic Ocean, open water absorbs sunlight, speeding the melt—an effect compounded by relatively warm, salty water pouring in from the North Atlantic.

▲ COLD PHASE 1960s

High pressure over the Arctic and weakening winds at high latitudes allow cold Arctic air to seep into midlatitudes, bringing hard winters. A strong clockwise gyre (winds and currents) in the western Arctic curbs the influx of warm, salty Atlantic water, keeping in a layer of fresher, colder Arctic water—insulating ice and inhibiting melting.



◀ DIMINISHING SEA ICE

The Arctic’s largest ice shelf broke in half in 2002, and the following year saw record low summer ice cover for the region. Predictions vary on the timescale of melting, but few deny the downward trend. So what’s to come? Some will benefit—from shortcut sea routes, more accessible oil fields, and new fisheries. But increased traffic and industry will take a toll on the oceans. And ice-dependent people and ecosystems are in for a rough ride.

If we care about change, someone has to

all this work, no one wants to come up empty-handed,” Russ says. Knowing what’s at stake, the ROV engineers work overtime to tweak the system into shape.

And on the seventh day, the waiting is over. The ROV finally splashes down for a long zig-zag trip through the water column. And though the depths appear relatively impoverished, they reveal some strange and wonderful things never before recorded here. In a trailer on deck, a half dozen notebook-toting scientists crowd around monitors to record the jellies and other pulsing pelagic life-forms flying by. Later they’ll see the benthic (seafloor) treasures: eelpout and sculpin fish, a ray, an occasional anemone and sponge, and long tracks in the mud where polychaetes (marine worms) made their way, perhaps yesterday, perhaps hundreds of years ago.

The remote view is eerie. It’s inspiring. But for the scientists it’s not enough—especially with a third of the trip already over. When attempts

to snag living animals in deep water with the ROV fail, the teams disperse, hoping for more dives to come, but for now they turn back to basics. The “mud group” relies on a box core—a cable-tethered, 200-pound steel container with a scoop jaw that bites a chunk from the seafloor on impact—to bring up loads of muck for sifting, archaeology-style, in search of life or remnants thereof. Russ reverts to an even lower tech solution. He goes fishing. “If we can’t go down to it, we’ll bring it up here,” he says, hauling up the remarkably primitive ring net—basically a nylon windsock sewn to a five-gallon bucket that’s dragged through the water on a cable. Seawater sloshes onto his boots as he lugs the bucket to the lab to take a peek at the sample.

The pelagic micro-zoo is enchanting: Candy red copepods, transparent larvaceans inside mucous “houses,” and tiny jellies whose cells refract light to create oily rainbows, their fragile tentacles askew after the wild ride to the

Marine Marvels



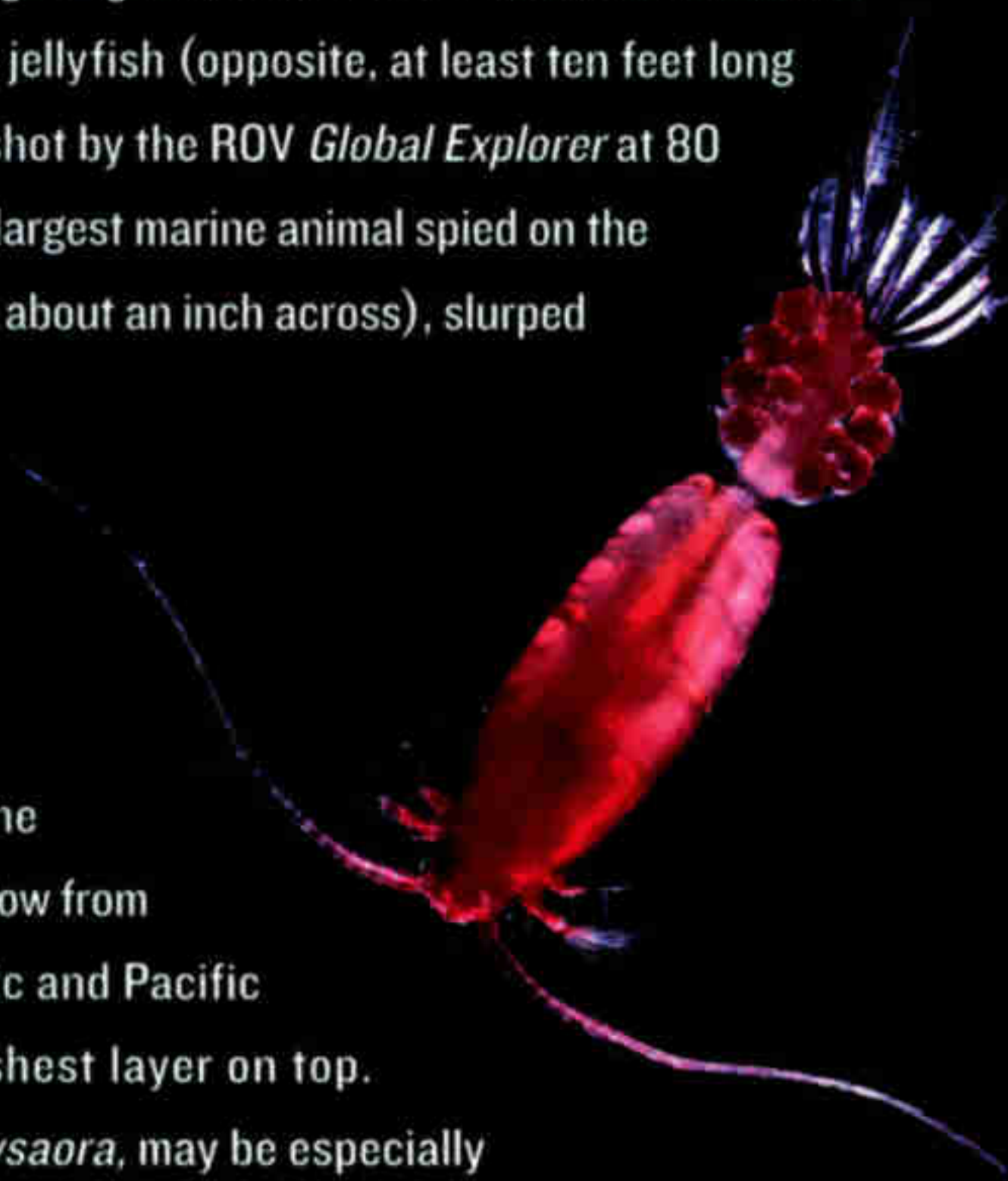
It’s a zoo down there, if you can get a good look. Canada Basin sea creatures include a glorious *Chrysaora* jellyfish (opposite, at least ten feet long from bell to tentacle tips), shot by the ROV *Global Explorer* at 80 feet. This sea nettle was the largest marine animal spied on the trip. A much smaller jelly (left, about an inch across), slurped

up blindly by the ROV’s sam-

pling wand, turned out to be a new species of *Narcomedusae* that awaits scientific description. Copepods like the hot red, inch-long *Paraeuchaeta* (right, with late summer egg mass) are abundant, making up some 90 percent of the

basin’s biomass. Arctic waters housing these creatures flow from various sources—including rivers and both the Atlantic and Pacific Oceans—and are stratified by salinity, with the freshest layer on top.

Animals restricted to a high-salt environment, like *Chrysaora*, may be especially vulnerable to the freshening effects of increased ice melt. For others, changing water temperature could prove bigger trouble.



record this stuff now. —Russ Hopcroft, Marine Ecologist

surface. Russ peers into the bucket with a flashlight, grabs an eyedropper, and slurps a single animal from the bouillabaisse into a petri dish, then slides it under the microscope.

Hunched over the scope, Russ has the mad scientist look down pat: thin red hair and beard disheveled, sky blue eyes and grin mischievous. An arrowworm, he says, gently poking the twitching, translucent sliver of a creature with tweezers. “It looks harmless, but check this out.” He zooms in and refocuses. “It has these teeth folded against the body that hinge out, like pocketknife blades.” Demonstrating, he grimaces for dramatic effect, snapping his forearms out, hands clenched into claws. “This thing’s an ambush predator, hunting mostly by sensory hairs along the body, which tell it something is in range. Then”—he seizes invisible prey and bites the air—“it strikes.”

But there’s more. The animal is heavy with young and amazingly begins to release them

then and there. Could this late season birth represent an adaptation to climate change—animals making use of longer summers—or simply a normal feat in this basin? Probably the latter, Russ says. Productivity blooms later in the Arctic than anywhere else. Either way, the data are invaluable, another bit of the baseline that will allow scientists like him to assess change down the line. “If we don’t get a handle on now, when we look in 2100, how will we know what’s happened?” Russ asks. “It’s like this: If the whole world were a city, how would we know that it used to be forests? If we care about change, someone has to record this stuff now.”

It’s not only about biology, of course. For the physical and chemical oceanographers, the sea pulses with other kinds of energy—shifting currents and temperatures, salinity-stratified waters, freshwater intrusions—the sea’s complex inner workings. Adding to a decade of





LOUIS S. S.



Built to rove where the big ship can't go, remotely operated Global Explorer dipped to 9,400 feet, shooting video and still photos of marine life in the pelagic and benthic realms. "The technology is on the fast track," says ROV engineer Chris Nicholson. "It will give scientists great access to the deep sea."

Big breakthroughs often happen just because you are there.

—Ian MacDonald, Oceanographer

data, scientists at each station have lowered a bulky rotunda of monitoring instruments called a CTD/Rosette (conductivity-temperature-depth), which captures a real-time, detailed snapshot of the water column and brings back samples, from as many as 24 depths, for analysis. Now, with the end of the trip looming near, it's time for one last epic undertaking.

Mary-Louise Timmermans fidgets on the bridge, tapping numbers into her calculator and checking data on her laptop. Her brown hair is slung back into a tangled, careless bun, her slender fingers moving at lightning speed. From up here she monitors technicians and crew assembling a 10,000-foot-long vertical mooring—a string of instruments, some tiny, some hefty, to be anchored in the water like a data-collecting charm bracelet. It will stay put for two years, promising priceless oceanographic information on temperature, currents, and ice thickness and movement—and a research paper for Mary-Louise, if all goes well.

“This gear is worth the next 20 years of my salary,” groans the young Canadian scientist. Down below, the crane shrieks, its arm dipping into the ship's hold to retrieve the various devices. Mary-Louise runs the show like the air boss on a carrier, calling down instructions on a walkie-talkie. Each piece must be placed at a precise depth, or the project could flop. Plus, the whole thing is hard to maneuver and the line extremely delicate.

“You can't be too careful,” Mary-Louise says. “The strand holding it all together is like dental floss. It can't be snagged or swiveled.”

Then, as if on cue, the walkie-talkie crackles with a frantic voice from below. The Kevlar lifeline of the mooring is nicked and could snap at any moment. “We have to put a man over the side to secure the line or we are

going to lose it!” someone yells.

Mary-Louise is gone in a flash. She races down three flights to where the crewman struggles to secure the precarious, dangling line. Others scramble to prepare a splice to replace the damaged length. Strong coffee makes rounds. The line is repaired.

Thirteen hours after the team began, in goes the caboose—that last orange buoy—and the massive string of instruments is yanked beneath the surface by the mooring's anchor spiraling to the ocean floor. The deed is done, and the deck explodes in cheers. Arctic field technician Doug Sieberg whips a loonie—the Canadian dollar coin named for the bird that graces its front—across the water like a skipping stone, a sacrifice to Neptune, he explains. He had thrown one in at the start too, to “grease the skids.” In triumph, he pumps a fist into the air. “For us mooring folks,” he says, “this is the pinnacle.” He swivels his hips and shuffles his feet, dancing happily.

And then, after more than 20 days at sea, the ship is steaming home—for the scientists, all too soon. Of course there's plenty to do on land: analyze samples, identify species, write papers. Once compiled, their oceanographic and biological data will provide a much-needed foundation for future studies. And months after the trip they will meet to reveal some intriguing results, including a new jellyfish species, a collection from the benthos of 10,000-year-old otoliths—fish ear bones—whose chemistry can fill in gaps in the climatic record, and a novel microorganism in the sea-ice brine that may dine on ocean contaminants.

WEBSITE EXCLUSIVE

View video footage of the strange, beautiful creatures that divers and scientists found under the Arctic ice at nationalgeographic.com/magazine/0401.



But visions of an isolated Eden have faded. The basin didn't pony up a fun house of oddities. Several moorings are in place (including the Japanese team's), promising years of data. But conclusions? Not yet. Is all the waiting, the frustration, the uncertainty of exploration worth it? Absolutely, says the mud team's Ian MacDonald of Texas A&M. "Big breakthroughs often happen just because you are there, and BOOM, something new," he says. "This kind of science encourages that kind of discovery. The peer review system doesn't really accept it, isn't happy with pure discovery. But that's how the best stuff often happens."

And so the journey ends, with the *Louis* anchored off Point Barrow, Alaska, the researchers awaiting helicopter transport to land, and an intense and welcome sun hitting the deck. A small group, having peeled off fleece and wool, gathers to watch a pod of bowhead whales blowing fountains off the starboard bow. These marine beauties, like a mother polar bear and

Today's Arctic ice melts earlier and freezes later than in decades past—easing ships' passage but altering a fragile ecosystem reliant on solid seas. What happens next lies over the horizon.

cub spotted days before on the ice, are clearly the ambassadors out here, obvious reasons to care about climate change. But behind the scenes lies the machinery, still poorly understood: the ocean's chemistry, its movements and sources, the transient ice, and the microbrewery of nutrients sustaining the copepods and cod that feed the seals. Without these there would be no breaching whale or great white bear.

A bellwether for global change and a pool of virtually untapped information, the Arctic Ocean may hold the key to the planet's future. It's also the perfect stage for a magnificent grand finale. The last night at sea, in a moment of clarity, brushstrokes of color streak the dusky sky, the aurora borealis bidding the visitors farewell. □

59631

Mining for Miracles

BY KIRA SALAK PHOTOGRAPHS BY LANDON NORDEMAN



People come to Basin looking for miracles: cures for rheumatoid arthritis, multiple sclerosis, depression, cataracts. From the highway, though, the tiny Montana town doesn't seem to offer much. There's just one exit, and a single long look reveals all there is to the place: a collection of weathered houses and old miners' cabins huddling close to the interstate, caught between the high peaks of the Elkhorn range. Basin looks like a place left behind on a whim. Were it not for its radon "health mines," Basin, population 250, would probably vanish back into the mountains as quickly as it came, left only in the memories of the boomers, or prospectors, who first called this place home.

Miners founded Basin in 1880, when it was nothing more than a collection of brothels, tents, and saloons in a Montana that hadn't even graduated to statehood. Law and order depended less on rules than on the

Sufferers of arthritis, asthma, and other chronic ailments gather in the Merry Widow Mine to inhale radon gas that seeps naturally into the old gold and silver mine. Some doctors say such "therapy" may be a cancer risk, but believers say the proof is in the pain relief.



strength of a man's fist. "They were a tough bunch of people, and they all liked to fight," says 68-year-old "Hap" Bullock. "There were cowboys on one side and miners on the other."

Hap claims Basin roots that go back three generations. He settles himself in his chair in the Silver Saddle Bar and examines me with the patient stare of a man who's seen more than his share of newcomers.

"Did *you* like to fight?" I ask him.

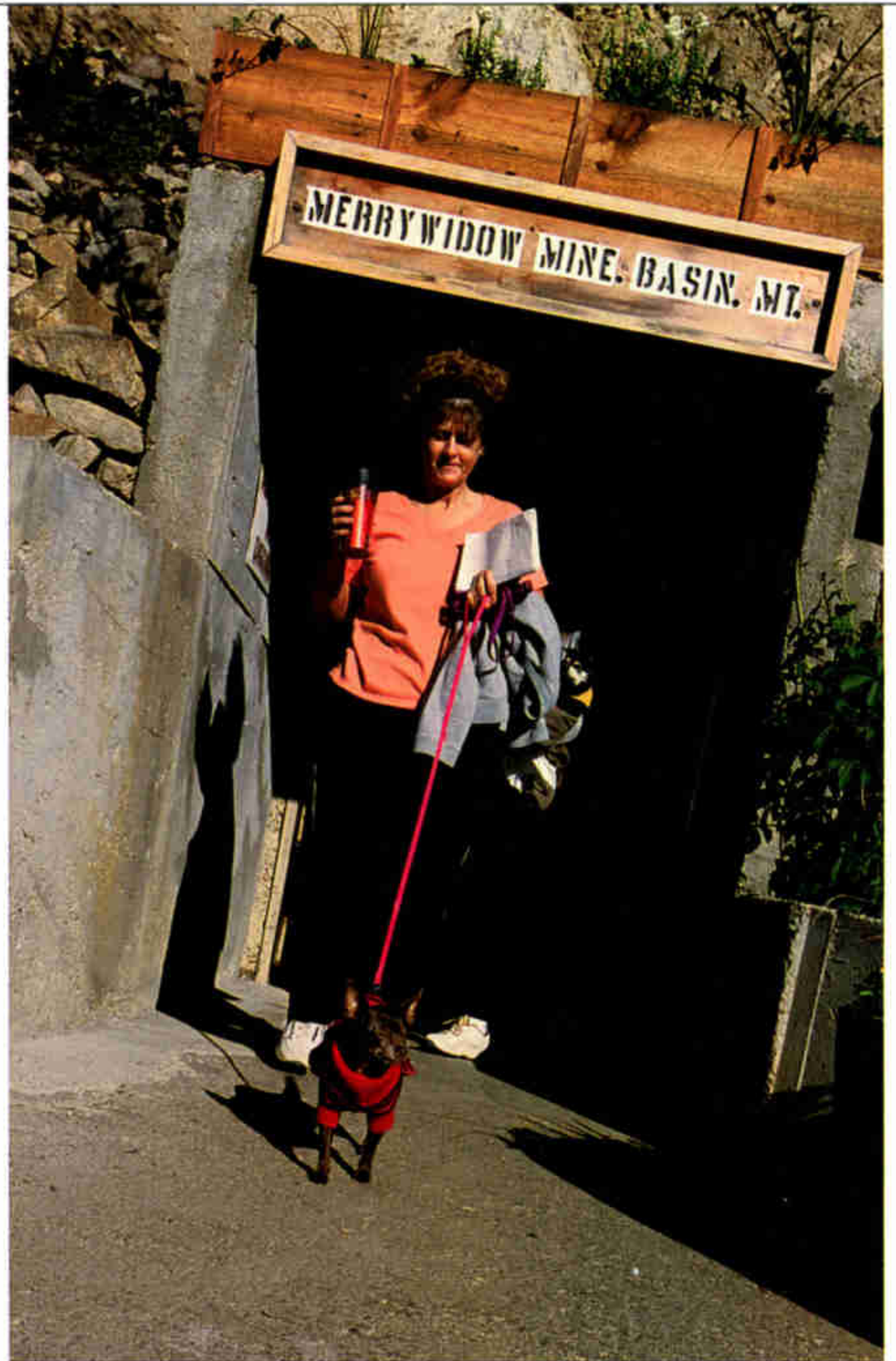
He gives me a slow grin and winks. "A little," he says. "We were looking to make a fortune. What you did is, you hollowed out a mountain and walked through it. I shipped 35,000 tons of gold, silver, and other metals from my mines."

You can still see evidence of Basin's late 19th-century mining heyday. Hike up in the hills and you practically stumble on tunnels abandoned during the gold fever search for bigger and better. Graves of Chinese laborers lie in unmarked mounds along Basin Creek. Ghost towns stare down on Basin from the high hills. Why did the town survive? Local legend explains it this way:

Someone once put up a small sign along the highway that said, "Basin—Heaven." If you saw the sign, you'd end up in Basin for life. "Every time someone crazy comes to live here," one resident says, "we say, 'Oh, they must have seen the sign.'"

I look for the sign along the highway but only see ones advertising the Merry Widow and Earth Angel Health Mines, two of the world's handful of radon mines. Believers claim that ten days in the mines, breathing in radioactive gas and drinking radioactive water, will cure a whole host of ailments.

The owner of Earth Angel, "Wild Bill" Remior, a disabled WWII veteran,



Mocha usually hobbles from arthritis, says Karen Weinstein. But after her annual dose of radon in the Merry Widow's Doggie Den, Karen says, Mocha runs. "Weird," says Karen. "Cold," says Derek Brown of his dip in the radon-laced water.



goes into the mine every day with his dog, Mr. Stup. “Now I seen a dog go in that mine that couldn’t hardly walk,” he says, “and by about the second day he was chasin’ rabbits. That was my rabbits that he was chasing.”

He’s referring to his more than 120 pet rabbits that live on the mountainside around the mine. When he leaves his trailer, they flock around him like he’s a latter-day St. Francis.

“Lady, I seen miracles go through this mine here,” he says, pointing to the 600-foot-long tunnel that cuts through the granite bowels of the mountain. “But what does it? I don’t know. Now, I cannot see the radon in there, and I cannot smell it, and neither can I see the good Lord nor smell him neither, but there’s something in there that does ya good.”

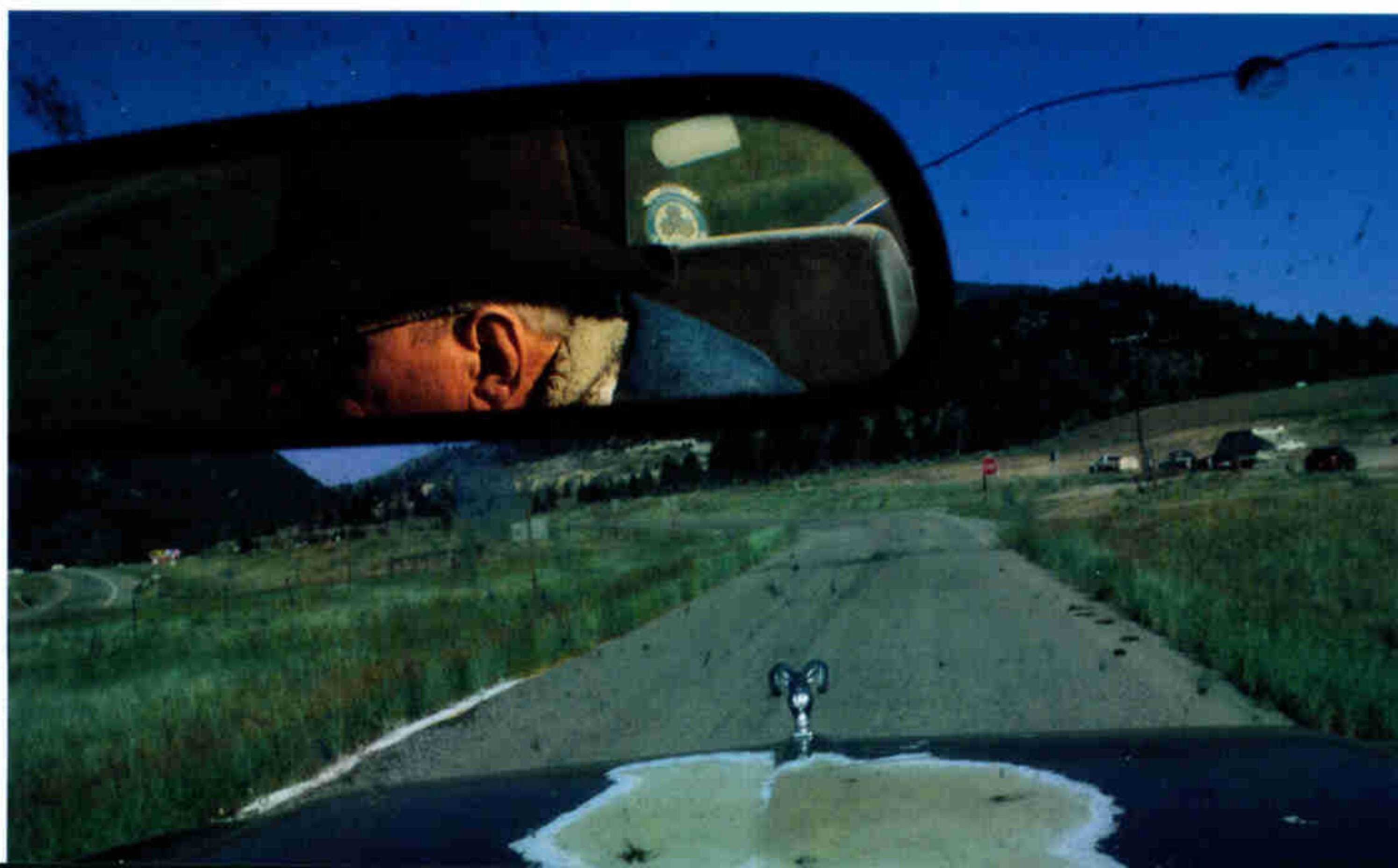
Even scientists who advocate the therapeutic use of radon haven’t studied how it works in Montana’s mines. Nevertheless, medical studies conducted in Europe, where radon spas have been popular destinations for more than a century, have shown beneficial health effects of radon treatments for various inflammatory joint diseases, including rheumatism and arthritis.

Still, the mainstream medical community and many laypeople in the U.S. find such claims unsettling if not downright dangerous, given the well-documented ill effects of high-dose radiation on the body. Yet ever since the Merry Widow became a health mine in 1952, hundreds of thousands of people have come from as far away as Germany, Korea, and Japan to walk 450 feet into the mine for one-hour “treatments,” three times a day.

Their signatures and messages cover the rock walls. Old bus seats line the sides of the mine to provide resting places for the daily crowds of 50 or more people during the summer months, with one passageway leading to the Doggie Den: a cubbyhole with built-in shower, where you can bathe yourself and your arthritic dog. At the end of the main tunnel,



At the Silver Saddle Bar, patron Stewart Andrews inspects a special edition Winchester rifle—just \$1,995, says the traveling salesman. Bill Shelton (below) heads for a radon mine in hopes of getting limber enough to mount a horse again.



59631

Helena
Basin

POPULATION: 250

POP. IN 1900: 1,400

NUMBER OF SCHOOLS: 1,
a one-room schoolhouse
with 20 students

**NUMBER OF ART
STUDIOS:** 4

**NUMBER OF VISITORS TO
MERRY WIDOW SINCE
1952:** At least 250,000

I find people soaking their hands and feet in basins of the frigid 44°F radioactive water, which they believe to be more beneficial than just breathing in the radon gas. A rack of magazines and board games helps visitors pass the time, their conversations creating a pleasant rumble down the mine shaft.

Being in these mines is like entering an odd sort of club in which everyone greets you with nods of congratulations and knowing. Because, they will tell you, miracles really have occurred here—and not just to the faithful or the lucky, but to nonbelievers as well.

“I was a nonbeliever,” says Sue Schuster-Johnson, who first visited the mine eight years ago from Nampa, Idaho. “I just came along with my Uncle Clyde for a vacation.” (Clyde, 94, has been visiting the mine nearly every year since 1962, when he says it cured his rheumatism.) “But when I got back from the trip, my migraines were gone for good—and I’d had migraines for most of my life.”

Sue collects clay from the walls of the mine, swearing that it heals skin infections. Most visitors end up taking some of the mine away with them: lichen or mold, water, mineral secretions—even little pillows filled with radioactive gravel. One man is said to have loaded up his truck with a hundred gallons of water for his racehorse.

Stories like Sue’s brought Tanya Beck from Duluth, Georgia. Her four-year-old daughter, Allison, suffers from progressive rheumatoid arthritis; her doctors, having run out of solutions, predict she will spend her life in a wheelchair.

“This seemed like our last hope,” Tanya says. “When we got here to the mine and I saw what it was, it was kind of like a *Twilight Zone* thing. I thought, there’s no way. But Allison is running and playing now. She hasn’t been hurting. She’s definitely getting better, and this mine has something to do with it.”

The other mine-goers and I have been listening raptly to Tanya. We all hope it’s true, that Allison is getting better. For the first time, I join in and drink some of the radioactive water along with everyone else. I figure it couldn’t hurt. □

Not everything is radon-related in Basin. Gentle strokes and a soothing whisper from Gay Peterson helped tame Peta, a wild mustang, which she finally mounted bareback (below). Her boyfriend, James Maher, looks on with grudging approval. “I’ll have to spend some time in hell for the way I used to train horses,” he says. But who knows? No judgment is ever final in Basin, where for many a doctor’s diagnosis is just a first opinion, and the mountains beckon with promises of a second chance.

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Final Edit



PATAGONIA

Where in the World?

A landscape painter couldn't have put together a more perfect composition: snow-streaked granite peaks, the moon hanging full and hazy beneath a cap of dark clouds washed with rose. Here in southern South America, where winds deliver ferocious storms and climbers can wait weeks for clear weather before attempting a summit, a moment like this occurs about as often as a blue moon. "The photograph sets a beautiful mood," illustrations editor Susan Welchman acknowledges, "but those mountains could be anywhere." Nothing identifies them as the Andes or places them in Patagonia.

On another night, in the foothills of the Andes, photographer Peter Essick shot spiky native araucaria trees outlined against the bright stars of the southern sky (page 75). "That picture," says Susan, "has mood *and* uniqueness of location," making it a better choice for a perfect ender for the Patagonia story.

WEBSITE EXCLUSIVE

Cut it or keep it? Find out more about what tipped the balance for this photo and send it as an electronic greeting card at nationalgeographic.com/magazine/0401.

ON ASSI

ON THE ROAD, IN THE FIELD

PATAGONIA

Hands of Time

Coming to grips with a lost civilization

For thousands of years the Tehuelche people roamed Patagonia, and in a deep canyon cut into the Argentine steppes, they left their ancient mark: hundreds of handprints, blooming on the walls in what is now called Cave of the Hands.

"They used a hollow bone to blow paint over their hands as they pressed them against the rock," explains writer **Simon Worrall**. "One joker even made

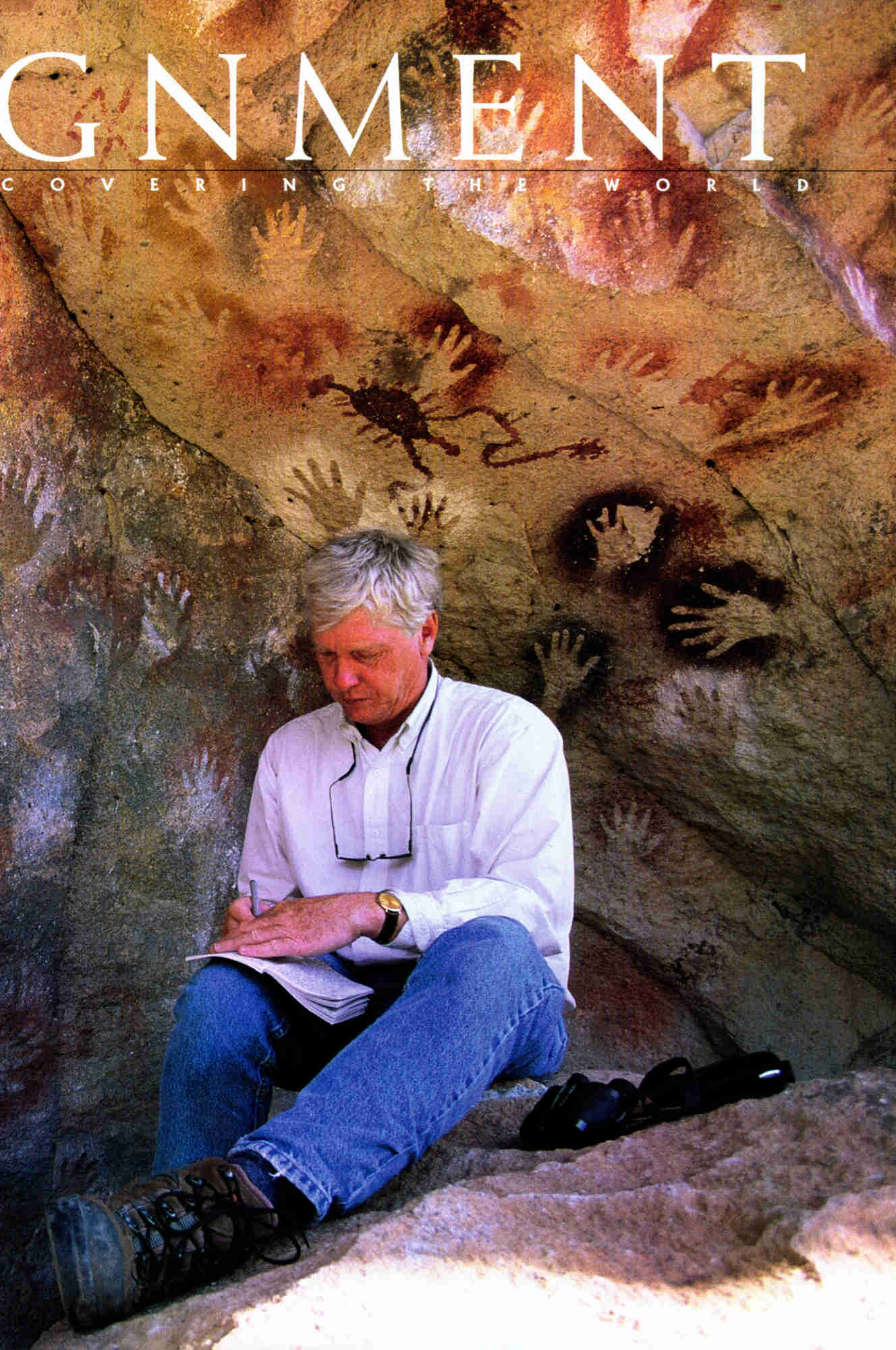
a print of his left foot." So whatever happened to the Tehuelche? "They were shot, poisoned, and driven off their land to make way for sheep farming in the late 19th century," says Simon.

The last Tehuelche died in 1960. In the Cave of the Hands, though, Simon sensed a strong presence of these original Patagonians. "I also felt sad that I would never be able to shake the hand of a living Tehuelche."

ANDRÉS SALINERO

GOVERNMENT

C O V E R I N G T H E W O R L D





LARS-MAGNUS EJEHOLM; EMORY KRISTOF, CONTRIBUTING PHOTOGRAPHER-IN-RESIDENCE (BELOW)

HANLE VALLEY

Wanderer With a Camera

He is a bit of a nomad himself, traveling the world as a photographer. So when **Mattias Klum** accompanied Lama Zotpa, a monk from Ladakh's Hanle

monastery, on visits to nomadic Himalayan herders, he felt a certain kinship with the wanderers.

"One month I'm up at 18,000 feet in the Himalaya, and the next month I'm hanging from

some tree in Panama to photograph kinkajous," says Mattias. Or hanging out with royalty: Last July Mattias received a special medal for excellence in nature photography from Carl XVI Gustaf, king of his native Sweden.

In Ladakh Mattias photographed one nomad family (left) gathered in their tent made of yak felt. All was well with them; they wanted only simple blessings from Lama Zotpa. But others Mattias met as he followed the monk had more pressing problems. "I remember a young woman who had a really bad toothache. Half her face was swollen, and she was in terrible shape. Since she was 30 years old, Lama Zotpa said a specific Buddhist prayer 30 times—one for each year of her life—to try to make her well."

WORLDWIDE

The *Louis S. St-Laurent* may be the largest ship in the Canadian Coast Guard fleet, but staff writer **Jennifer Steinberg Holland** (right), on board for almost a month to report on the craft's Arctic explorations, remembers some cramped quarters. The "sliver



of a room" she shared with one of the expedition's scientists held bunk beds and a sink. "For the two of us to be in there at once, one of us had to press up against the wall so the other one could squeeze by."

Up on deck, "there was usually nothing but ice, sea, and sky as far as you could see," Jenny says. "Then one night, with the ship at rest in the middle of nowhere, I

saw a lone polar bear. It had to have come a long way by itself to get there." Jenny felt a bit of the bear's isolation herself. "It was both disconcerting and freeing to be so cut off from the outside world. We didn't even have e-mail communication," she says. "It felt

like we were the last people on Earth, and this bear had come to say goodbye."

Writer **Kira Salak** says she breathed a little easier after visiting the radon mines of Basin, Montana. She says that the radiation that yearly touches thousands of visitors to the town's mines seemed to help her allergies and asthma. And though many

scientists don't buy such claims, she's not alone. "I met people there with terrible illnesses who said they were helped by going into the mines," says Kira. "Some of them were even taking sick pets in with them, and they said the animals seemed better too."

Kira was so intrigued by Basin's radiation cures that she continued to research the subject after she'd finished her article. She found that scientists and medical doctors have been studying the effects of low-dose radiation on the immune system, and some of their findings seem promising. One problem: Radiation levels in the mines, say some experts, are too high to be beneficial.

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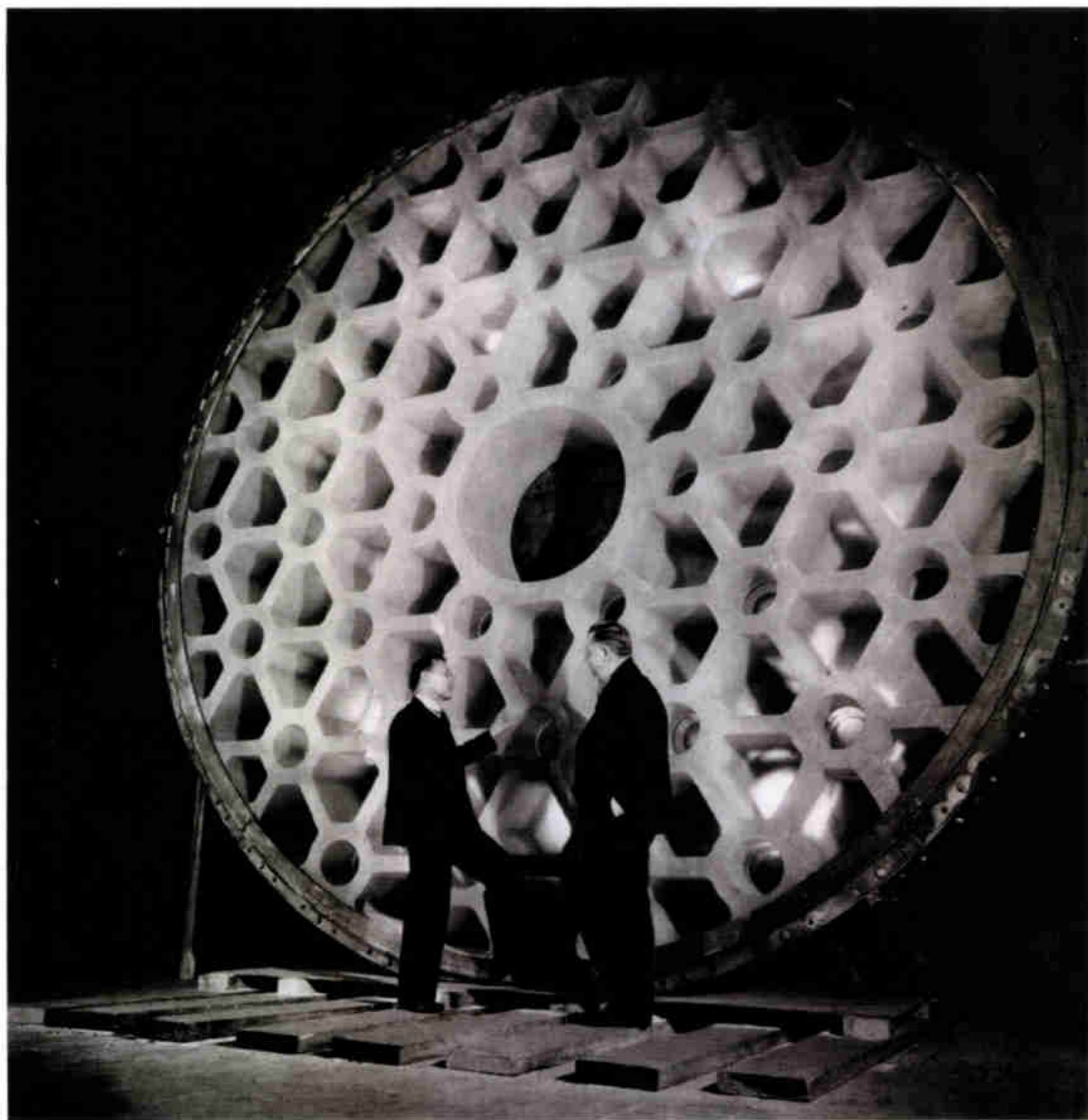
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Flashback



ROBERT YARNALL RICHIE, CORNING GLASS WORKS PHOTO, CORNING, NEW YORK

SKY DISK

A Blank Look

The back resembled a 20-ton waffle, but it was the front of the 200-inch Pyrex “mirror blank” that absorbed New York–based Corning Glass Works physicist George McCauley, at left, with associate J. C. Hostetter. Though his first attempt (above) was flawed, McCauley’s second try was successful; he babied that disk through flood, ridicule, and a rare upstate New York earthquake. In March 1936 he moved it to California, where it was polished to concave perfection (an 11-year process) to reflect and focus light in the Palomar Observatory being built near San Diego. In 1948 engineers installed the disk at Palomar—the world’s most powerful optical telescope until Hawaii’s W. M. Keck Observatory opened in 1993. Today Palomar still gives astronomers a nightly star-studded show. —Margaret G. Zackowitz

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A black and white photograph of a man and a young boy laughing together. The boy is sitting on the man's shoulders, and both are laughing heartily. The background shows the wooden framing of a building under construction, with vertical studs and some blurred lights.

This is a picture of a home
building a family.



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